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Contents.

	PAGE
Transverse and Other Tests for Cast Iron	351
Eliminating Extraneous Matter	351
Catalogue Received	352
Book Review	352
Correspondence	352
Random Shots	352
Foundry Costs	353
Luther's Connections with Ironfounding	359
Design and Patternmaking in Relation to Efficient Production of Castings	355
Direct Labour Costs in Cast Iron	356
Steel Castings Conference	356
A Symposium on Steel Castings	357
A Note on Safety First in the Ironworks	359
Institute of British Foundrymen	360
Steel Castings for Severe Service	362
The Wet Process of Vitreous Enamelling	363
Mr. Henderson Addresses Burnley Technologists	365
Plastic Contour	366
Braintree Claims New Record	366
Abrasive Papers	366
Volume Changes in Cast Iron	366
Trade Talk	368
Obituary	368
Contracts Open	368
New Companies	368
Patent Specifications	368
Personal	368
Open-Hearth Investigations of the United States Bureau of Mines	370
Iron and Steel Markets	370

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

NOVEMBER 20.

Sheffield Metallurgical Association:—Ordinary meeting at Sheffield. "The Welding of Stainless Materials." Paper by H. Bull and L. Johnson.

NOVEMBER 21.

Newcomen Society:—Annual general meeting in London. "Statistical History of the Iron Trade," A.D. 1717—1765. Paper by E. Wyndham Hulme, B.A.

NOVEMBER 23.

West of Scotland Iron and Steel Institute:—Ordinary meeting at Glasgow. "Hartmann Spiral Bricks." Paper by Messrs. Tornblad and Mitchell.

NOVEMBER 27.

Institute of Metals (Birmingham Local Section):—Ordinary meeting at Birmingham. Paper by D. F. Campbell, M.A., A.R.S.M., on "Electric Furnace Developments."

Institute of British Foundrymen.

NOVEMBER 17.

Lancashire Branch (Junior Section):—Ordinary meeting at Manchester. "Shrinkage Holes in Small Grey Iron Castings." Paper by P. A. Russell.

Scottish Branch (Falkirk Section):—Ordinary meeting. "Blacking, Coal Dust, and Light Castings." Paper by J. M. Primrose.

NOVEMBER 23.

Scottish Branch (Paisley Section):—Ordinary meeting. "The Cupola." Paper by A. C. Miller.

NOVEMBER 24.

East Midlands Branch:—Ordinary meeting at Leicester. "The Engineer and the Foundryman: What's Gone Wrong?" Paper by W. H. Poole.

Transverse and Other Tests for Cast Iron.

The paper given recently to the Iron and Steel Institute by the Director of the Cast-Iron Research Association on the "Use and Interpretation of the Transverse Test for Cast Iron" carries a stage further papers presented last winter to the West of Scotland Iron and Steel Institute and the Sheffield branch of the I.B.F. In the new paper a fact of considerable importance emerges, and yet one which we believe is not appreciated by most foundrymen; that is, the relationship between the tensile test and the transverse test. The majority of founders are familiar with both tests, and yet, because the tensile is worked out in tons per square inch, while the transverse is left as a breaking load in pounds or tons, there appears to be no connection between them. A valuable check is thereby lost, because if the relationship is not what it should be the founder would immediately know that one test or the other was in error.

Working out the transverse test in tons per square inch is not a very difficult operation, and it appears that when this is done the transverse test has a value about double that of the tensile test. The figure is not exact, but seems to be in most cases between 1.8 and 2, which still offers a very good means of checking one test from the results of another. It does not seem that any exact figure can be obtained, for the simple reason that the transverse test is invariably made on the full section of the bar, whereas the tensile test has of necessity to be made on a machined bar. In most standard specifications the amount recommended for machining off varies, so that, for instance, the tensile on the 0.875 in. dia. bar, which is machined to 0.564 in., is not structurally comparable with the tensile test on the 1.2 in. dia. bar, which is machined to 0.798 in. The B.E.S.A. chooses 0.564 in. dia., of course, for the reason that it is exactly 0.25 sq. in. in area, just as the 0.798 in. bar is 0.5 sq. in. in area. This facilitates the calculation of the tensile value in tons per sq. in. from the breaking load in tons. Thus the relationship between the transverse strength of a 1.2 in. bar to its tensile cannot be quite the same as that between the transverse and tensile results on a 0.875 in. bar. Apart from the alteration in transverse strength of the two bars, due to the different rate of cooling in the different diameters, such variations in tensile dimensions are bound to affect the tensile strength. It is somewhat remarkable, under the circumstances, that the relationship should be within the comparatively narrow limits of 1.8 and 2. If tests were taken on skin-machined transverse bars and tensile tests taken on the broken portions, taking care to remove as little metal as possible in the machining for tensile and always keeping a constant ratio of original diameter to machined diameter, it seems likely that there would be a still closer relationship between the two tests, at any rate for one kind of iron.

Then the average foundryman would realise that from any transverse test he could assume with reasonable accuracy the tensile strength of his metal, or alternatively, that from the tensile strength he could obtain the transverse breaking load of a particular sized bar.

A number of foundrymen are somewhat disturbed at the spread of fabricated structures which are being used as bedplates and casings, and in other applications in place of castings. We believe that the development of the work outlined in this paper will enable this competition in a measure to be met, because it will enable castings to be designed, perhaps for the first time, on a really rational basis, putting metal exactly where it is needed in the thicknesses required, without any surplus or margin, which merely increases the weight and cost without serving any useful purpose. A knowledge of the precise mechanical properties of cast iron, such as is given by determination of strength in varying compositions, will enable a smaller factor of safety to be employed with success. The industry, however, must give designers full information.

Eliminating Extraneous Matter.

Ever since Mr. John Shaw presented his Paper to the summer meeting of the American Foundrymen's Association, the situation of theoretical consideration of cast iron, has become more complicated. Arising from the discussions, the following questions have been posed. (1) Are experiments carried out on small quantities of synthetic mixtures of pure materials really helpful? (2) Are conclusions drawn from diagrams based on the summation of silicon and carbon contents of great value? Is the control of the matrix of more importance than the control of the graphite formation? Is the condition of the graphite dependent on the nature of the carbides resulting from composition or thermal history? Can the recently discovered critical manganese percentage be definitely stated on theoretical grounds? Can the low-carbon high-silicon development be related to one of the existing theories? Can the superheating theory be definitely substantiated? Is the gas content of cast iron to be taken as a serious factor? Is ingotism of paramount importance? Are internal stresses receiving their quota of consideration in discussing some phenomena? Can free graphite exist in normal cupola-melted iron?

It is obvious that further Papers are needed which will clarify our ideas and indicate the car-

dinal points for further study. At the moment, if a seeker after truth works with small quantities, then the "mass" experts immediately bring up their heavy artillery and decimate any theory evolved as being unrelated to practice. Inversely, a person outlining his theories based on experience with heavy masses of metal is attacked on the grounds that no single factor has been adequately and indisputably established, let alone standardised and controlled, so that proper comparisons cannot be made.

We suggest that it is high time that a questionnaire was drawn up and submitted to the recognised authorities with a view to obtaining at least relative agreement as to which are the dominant factors for immediate study. As a forecast, we predict that the matter would tend to revert to an intense study of equilibrium diagrams, from which eventually a complete understanding of the whole subject will be forthcoming.

Catalogue Received.

Foundry Plant.—We have received from Messrs. Augusts Muffle Furnaces, Limited, of Halifax, a binder containing a number of loose sheets and two folders. The loose quarto sheets are standardised inasmuch as they illustrate a nationally known article, and beneath a photograph of a portion of the plant Augusts have supplied to aid its manufacture. A typical case is that showing a Leyland omnibus, and below it three muffle furnaces which contribute to its production. This is a very effective method of publicity when associated with a series of newspaper or technical journal advertisements, but we feel that for a catalogue much of the value is lost by a sort of substituted reiteration, and after scanning the first two or three, attention appears to get concentrated on the top picture just to see where sales have been made and not to ascertain the type and magnitude of the orders received. We suggest that for a catalogue a classified list of plants supplied and their location is adequate for impressing the reader as to the serious and imposing nature of their business. Then this is best supplemented by technical data of an interesting character, for after all an expensive production, such as this catalogue undoubtedly is, should be filed for the technical and commercial data it contains, whereas, the appearance of these sheets in the form of a series of advertisements in the press does arouse interest in the question and induce an attitude of curiosity, so that he wishes to have by him the technical details of the plant. This phase must have been realised by the issuing company, as the two folders tell interesting stories about (1) mould and core drying, and (2) sand preparation and handling. In short, just the material one expects to find in a catalogue. Though we find it necessary to criticise the general plan of these publications, we have nothing but praise for their general presentation, and especially are the illustrations worthy of commendation.

Book Review.

Kelly's Directory of the Engineering, Hardware, Metal and Motor Trades throughout England, Scotland and Wales. Published by Kelly's Directories, Limited, 186, Strand, London, W.C.2. Price 45s.

This well-known publication, in its 18th edition just published, well maintains its reputation for completeness and reliability. The scheme adopted is to present a list of manufacturers in the English and Scottish counties, and then London and the suburbs. These are followed by classified trades for the whole of the provinces. There are finally two coloured sections, the first of which is devoted to a list of the iron and steel sections rolled by the various manufacturers, and the second a list of proprietary articles and trade names.

A Cancellation.

The Council of the Burnley Section of the Institute of British Foundrymen has decided to cancel the November meeting at which Mr. Flower was to read a Paper on "Mould Gases."

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Transverse Tests.

To the Editor of The Foundry Trade Journal.

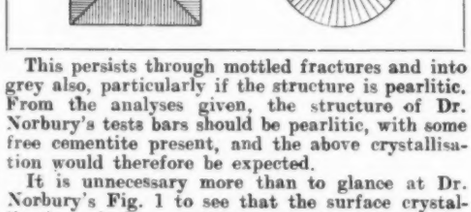
Sir,—In criticising the Paper on "The Use and Interpretation of the Transverse Test for Cast Iron," by J. G. Pearce, read before the adjourned meeting of the Iron and Steel Institute in Birmingham, on Thursday, October 25, I accepted the author's statement with reserve respecting the comparative results of certain square and round test bars, and suggested his giving full information. Dr. A. L. Norbury gives this information on page 328 of your issue of the 1st inst., and these confirm my suggestion that different results might be expected in round *v.* square bars in such an investigation.

Dr. Norbury suggests that the formula used for the modulus of rupture is not strictly applicable for comparing the strength of round and square bars, but in his partial reply to criticism on the 25th ult., Mr. Pearce held that the formulæ themselves were correct, giving blackboard illustrations for his reasons.

The research by Adamson and Bell, to which Dr. Norbury refers, show that Unwin's formulæ are not suitable for converting a breaking load of one section of transverse bar to another section whether it is square, oblong, or round. Dr. Norbury accepts these results, and therefore, should the modulus of rupture formula used by him not be applicable for comparing results of round *v.* square bars, as his formula is based on that used by Adamson and Bell, it will be equally unsuitable for comparing different sizes of round bars, except as giving an *empirical* figure, which therefore would be of no value to engineers.

In the Adamson and Bell tests all the bars of whatever section or size were strictly comparative in skin structure—in each section—but those given by Dr. Norbury are not equally comparative, for two reasons, (1) it was shown in the Adamson and Bell Paper than when $\frac{1}{16}$ in. was machined off the surface the tests fell, and (2) Dr. Norbury does not appear to have taken into account the possibility to which reference was made in my criticism of Mr. Pearce's Paper, and which, strangely enough, is emphasised by Dr. Hanson in his Paper, reported on page 319 of your issue, *i.e.*, crystallisation due to chill, which might be expected in low silicon irons. *Because of this*, differences in the results obtained from square bars cut from round and *vice versa* might be expected. Hence this possible difference might be at least a contributory cause of variation.

It is well known that white iron, on cooling, crystallises as follows:—



This persists through mottled fractures and into grey also, particularly if the structure is pearlitic. From the analyses given, the structure of Dr. Norbury's tests bars should be pearlitic, with some free cementite present, and the above crystallisation would therefore be expected.

It is unnecessary more than to glance at Dr. Norbury's Fig. 1 to see that the surface crystallisation of the round bars cut from the square would vary, and that the hypothetical skin stress (modulus of rupture) would depend on where the load was applied. Also, the grain size of the square bars cut from the round would vary on each side between the corner end and centre of the surface.

Bearing these points in mind it would be interesting to carry the tests further before coming to any definite conclusion.

Yours, etc.,

E. Adamson.

18, York Street, Sheffield.
November 7, 1928.

Random Shots.

When the layman describes a process or a product which he knows only superficially the result is apt to prove quaint hearing or reading for the expert. A highly respected provincial contemporary this week endeavoured to describe the process of bell founding in connection with some recasts of certain church bells, and the effort was amusing. The "furnace of regeneration" was a "furnace of whitewashed brick in a surround of dinginess inseparable from the work of a foundry." He went on, "last night about half-past twelve coal fires were lighted beneath the cauldron containing the last pieces of the broken old bells. By noon to-day the metal was in condition for casting."

* * *

"Deep in the floor in front of the furnace moulds cased in iron had been sunk. The preparation of those moulds had been a long business. They had been made to scale, so that the thickness of the bell in its every fraction of an inch should approximate to the note required. Meticulous calculations now take the place of the rule-of-thumb methods of long ago."

* * *

Things now begin to get exciting. Sometimes it has a touch of Shakespeare, sometimes of a foreign translation. "With everything in readiness a valve in the furnace cauldron was opened. Out spurted a jet of molten metal. It fell into a channel of foundry earth and flowed down to an open mould. When one mould had been filled the white-hot stream was diverted into another channel and the second mould filled."

* * *

An interesting development, of special interest to ironfounders, is that of the Diesel-electric locomotive, about which Press references have been seen this week. A usual argument against electrification of main lines is the heavy capital cost of overhead lines and tracks. This new locomotive, or electromotive, as I should perhaps call it, will do for the railway what the omnibus and charabanc have done for the roads against trams.

* * *

By the way, we have heard very little recently about turbine-driven locomotives and locos fitted with condensers.

* * *

Visitors to New York are generally familiar with the subway system, the equivalent to our "Underground," but very much duller and darker to travel on. It runs north from the tip of Manhattan Island for several miles. Slow trains stop at all stations. Expresses only pull up at important points like Times Square. A New Yorker was demonstrating the value of American hustle to a Japanese, a race which has not yet completely lost its dignity and poise under pressure of Western ideas. They took a slow train from one station, and when it pulled up at a junction, by a desperate effort the New Yorker was able to get out of the slow train into an express which had halted for a few seconds on a parallel track. They were whirled north, and the American turned with pride when they reached their destination.

"See, we have saved two minutes that way."

"Yes," said the Jap, "I see; but when you have saved it, what do you do with it?"

* * *

New Alphabet for Ironfounders.

(Continued.)

Q is the Quality never in doubt
Of every fragment of work we turn out.

R's for the Riddles that sometimes occur
And cause to go flying both feathers and fur.

S is for Sand that is dirty and black,
To deal with it nicely requires quite a knack.

Marksman.

Foundry Costs.*

By J. Lucas.

Whilst the majority of foundrymen were keenly interested in obtaining and studying the best and latest methods of foundry practice, and busily engaged in the production of castings from the various metals, there was little time left in the ordinary day's routine to consider detailed costs, and it was often left to the office management, with the result that should costs be mentioned to the foreman he sometimes got his "back up," and imagined that his foremanship was being attacked; but that, in most cases, was far from being a correct view of the matter. The membership of the Institution included foundry-owners, managers, foremen, charge-hands, moulders, apprentices, metallurgists, chemists, pattern-makers, etc., and while to some costs were a very vital factor which they realised, there were others who had practically no interest at all in the matter, probably because they thought it was no concern to them, or because they were apt to regard it as either not entirely necessary or a nuisance. Still, in all well-managed establishments the matter of costs should have as equal importance as the production of good quality work. The author pays tribute to the articles on "costing" which have from time to time appeared in THE FOUNDRY TRADE JOURNAL. The German Foundry Owners' Federation had considered the subject very closely, and evolved a system for arriving at costs, and the foundries of the United States had also been giving serious attention to the subject of late years.

The large variety of goods which the foundry industry produced, he said, ranged from castings weighing less than one ounce up to 90 tons or more, from the toy lead soldiers up to the mighty bronze statues, and from the basest metal up to fine gold, and in all of their great variety there were the same materials and labour sections—the metal, mould, moulder, the core and core-maker, the dresser or fettler—who all had their parts and contributed to the ultimate aim of producing sound castings. Metals and melting dealt with the final cost of the metal in the casting, and to arrive at this there was a diversity of opinion. One method was to find the cost of the liquid metal as it was poured into the mould, which was arrived at by adding the cost of the metals used to the actual costs of melting. Although this method appeared to be very straightforward and simple, it was, however, likely to mislead. They all knew that the cupola would consume more coke on some days than on others, and the price of metals might vary from one month to another, or perhaps a cheaper quality of iron may be required on some jobs than on others. Those fluctuations may probably be unnoticed when the cost of the metal as poured was taken. The method apparently most favoured was to find the actual cost of the metal as apart from the melting costs. For example, a total melt of 120 tons with a 5 per cent. loss in melting and a scrap return of 24 tons, gave a net production of 90 tons of good castings. If the castings in the shop required different mixtures of metal, then, of course, the several mixtures would be taken separately for metal cost.

In an article by Mr. Jobson, which appeared in THE FOUNDRY TRADE JOURNAL about four years ago, the opinion was expressed that the best way to arrive at the cost of the metal in any casting was to take not the actual weight of the casting itself, but the weight of the casting plus the runners and risers necessary to pour it. Mr. Jobson gave examples demonstrating how the metal in a casting requiring its own weight in runners and risers, would cost more than a casting which required, for instance, 25 per cent. of its own weight in runners and risers. Mr. R. E. Belt has given a very lucid explanation of this, and submitted examples which, he said, may be the extremes, but still they bore out Mr. Jobson's contention that to ignore the remelt of runners and risers was a serious matter.

Where the cost of the remelt was ignored it was proved conclusively that runners and risers were a very vital factor in foundry costs, and one which was dangerous to ignore. It was a common practice for the moulder to look upon the runners and risers merely as so much scrap metal which could easily be returned to the charging floor and remelted, but it was entirely an erroneous view, and one, which, if properly understood, would induce more care to be taken in fixing and shaping of runners and risers, particularly so in repetition or plate work. Runners and risers should not, however, be reduced to such an extent as to endanger the production of good castings, but much metal could be lost and excessive cost incurred by the indiscriminate use of them.

Fuel Consumption.

With regard to fuel consumption for the cupola, this question, he said, could with advantage be more carefully considered by those responsible for the melting. If the coke, both of bed and charges, was carefully weighed instead of being thrown on by guess, a surprising difference would soon be found. The extra trouble taken in weighing was only small, and it was surprising how far safer and reliable one felt in the knowledge that only the correct amount of coke would be used. Obviously foundries doing entirely different classes of work must have different cost methods, but still the main factor applied—the cost of the metal must first be found. In heavy castings where the runners and risers were small in comparison to the weight of the casting, it may be wise to ignore them altogether, but in the light castings foundry these certainly did require to be taken into consideration.

Cost of Wasters.

With regard to moulding this was rather a more simple proposition, dealing practically only with the direct wages paid for actual moulding work or time, and could be easily calculated. The total wages paid to the moulder may be calculated over the whole shop if the work was much of the same nature, or in sections, according to the types and varieties of work. Few moulders, he thought, realised that the loss to any foundry caused by wasters was the difference between the selling price of a good casting and the buying price of outside scrap. If the men on the floor could only thoroughly appreciate this point there would be less wasters in the foundries. It must not be inferred that all wasters were the moulder's fault—far from that—but still they all knew of many castings which were scrapped through forgetfulness or carelessness on the part of the moulder. The cost of castings being taken on good castings produced, the wasters, however small the percentage may be, were bound to increase the cost of the god castings. The waster problem was one that no foundry could afford to ignore.

The author has studied many systems, and it was rather strange that the question of wasters was hardly considered at all, but Mr. R. Dunkerley, speaking to the members of the Lancashire Branch, declared "it is best to eliminate from the costs the expenses of both time and material which have been expended on wasters and charge the figure to general overhead." The question arose as to whether this natural risk was the correct procedure, as undoubtedly by charging the value of wasters to overhead, the overhead percentage was increased and so augmented the cost of the whole product. But, considered from a practical point of view, it was reasonable to assume that a certain amount of wasters were a normal condition in production, and it was an accident in the majority of cases that the wasters were on one job and not on another, and, therefore, it was only fair that all castings should bear their proportion. The only correct thing to do was to rebook the time against any particular job on which the original costing was made, and for a credit note to be passed through cancelling the cost of the scrapped work. This procedure would be the same whatever the cause of having to make a replace casting may have been. There was, however, the simple and easy way of taking the weight of good castings produced over a period of, for instance, four weeks, and divide into the total direct moulding wages to arrive at the cost per cwt. of moulding, and this, for nearly all practical purposes, would give a fairly accurate cost, providing always that the castings were of fairly uniform proportions and that no excessive amount of wasters occurred.

Operations incidental to core making, like moulding, dealt primarily with the direct wages paid to the core makers. In those foundries where the amount of core making was relatively small, or where the moulders made their own cores, the wages paid for core making could be lumped together with those paid to the moulder, but in those where core making was really a separate department the cost should be kept entirely separate from that of moulding. The trend of modern foundry practice was towards machine moulding, and it was a well-known fact that in order to mount patterns for successful use on moulding machines it was often found necessary to resort to cores to take care of undercut portions and uneven joints. Unless core-making costs were carefully recorded, the most careful of foundry managers may find that, while his moulding costs were down there was a corresponding increase in his core-making costs. When they considered the amount of trouble involved in coring up a mould, the risk of cores moving, the extra fettling work which was always found round cored joints, and the risk of wasters occurring through faulty or misplaced cores, they should think twice before introducing too much core making. He was not decrying the use of moulding machines, but he claimed that in the making of plate patterns for moulding machines, core-making work could very easily be increased if a careful watch was not placed upon it.

Oil Sand Cores.

The use of oil-sand for cores had greatly increased of late; in fact, some foundries were using nothing else. Oil sand, however, was likely to become a luxury and cause a soaring up of core-making costs if not closely watched. In districts where natural-bonded sand could be obtained fairly cheaply, he could not see why, for large plain cores, it should be discarded in favour of oil sand. It all depended on the class of work and the location of the foundry with regard to sand quarries, but, his point was that cores could be made to cost more by indiscriminate use of oil sand. In most published costing systems the preparation of sand was taken as an indirect and applied as an overhead charge, but whether rightly or wrongly records were worth taking to find out exactly the cost of new sand used per ton of good castings produced. New sand and coal dust were items which could put up the cost if used indiscriminately, so it was good practice to record sand mixtures and allow sand to be mixed only in one department, and under recognised rules. To allow the indiscriminate use of new sand and coal dust by individual moulders led to extravagance, which ultimately led to increased costs.

Fettling, Dressing, Cleaning and Annealing Costs.

In those foundries where annealing was an essential item to their product the costs of this might form a separate unit, but fettling or dressing, cleaning and sand blasting were common to all foundries, and could be taken as a separate department and the cost in labour per cwt. of good castings arrived at. Some foundries, however, preferred to take their fettling costs as proportionate to their direct moulding costs, asserting that where the introduction of many cores took place the castings were more intricate and the moulding cost was higher, and, therefore, the fettling cost must be higher.

The elements of cost could be subdivided into

* A Paper read before the East Midlands Branch of the Institute of British Foundrymen, Mr. E. Stevenson presiding. The Author is Foundry Manager to Messrs. Herbert Morris, Ltd., of Loughborough, and a Vice-President of the Branch.

two main heads: *prime cost*, comprising (a) direct materials; (b) direct labour, and (c) direct expenses, or, all direct expenditure in labour, materials or services which could be definitely traced to specific customers or production order. (2) *Oncost*, comprising all works and office expenses, unproductive labour and maintenance, materials, or all indirect expenditure which could not be definitely traced to a specific article or job, and which must, therefore, be spread over all the work. All expenditure which could be directly traced to a specific job was termed prime cost, and that directly traced, as oncost. Oncosts were divided into two sections—standing charges and variable charges. Standing charge took care of such things as rent, rates, taxes, insurance, depreciation, etc., which were usually more or less out of the control of the foundry manager. The variable charges were very wide and under the direct control of the foundry manager.

All details of expenditure could be closely watched and compared over definite periods and many economies thereby effected, and, in conjunction with piecework or daywork time records, which, if accumulated over fairly long periods, provided an invaluable record for figuring out time allowances on new work, which had to be done at a definite price, while estimating was made easier and safer for standard or special work. Most foundries had job cards or slips of some description which showed the time taken on any job, and which were used not only for getting at the time used on moulding or to work out piecework account, but also show the time actually used on productive and unproductive work, and so provide the nucleus of a cost system.

Much economy could be effected by interworking of the foundry manager with the buying department, and it was up to that department to purchase at the most favourable times and rates, though it was false economy for the buyer to purchase inferior goods which would give rise to trouble and obvious increase in production costs of the ultimate product, but this could be avoided by a good understanding between the foundry manager and the buyer, who should work together closely on such matters.

Customers' Patterns.

Patterns supplied to foundries by their customers were the property of the customers, and, as such, their cost did not figure in any foundry costs, but where the foundries using these patterns were responsible for their care and upkeep, careful records of the costs of any repairs effected would need to be taken, and these would be charged as an overhead or oncost. Where the customer supplied a pattern which the foundry considered was not a suitable one for their productive methods, and decided to make their own patterns, the cost of these would be an overhead or oncost charge.

The costs to a foundry manager should be regarded more as a safety valve than anything else. By taking costs such as he had endeavoured to demonstrate, a manager would be able to know exactly and definitely what proportion of costs each department was responsible for, and, if the costs were taken on every four weeks, he would be able to make a comparison which would be invaluable to him if at any time he was called upon to estimate out any job in anticipation of future orders.

The author desires to express his thanks to their past-President and to Mr. Moore for the helpful criticism, advice and suggestions, and through the Journal wishes to acknowledge with thanks his permission in having allowed him to incorporate one of the various tables used in the Oncost system at the works of Messrs. Herbert Morris, Limited.

DISCUSSION.

The Chairman paid tribute to Mr. Lucas in having prepared such an excellent and instructive address. It was certainly one of the best on the subject he had heard, and had undoubtedly provided many points which they might discuss with benefit to themselves and the industry in which they were engaged.

Mr. W. Hammond asked if Mr. Lucas would treat labour such as was a necessity in a foundry as an on-cost or direct charge. If it was treated as direct labour then these same labourers were sometimes engaged in assisting moulders, carrying cores and pouring metal. Mainly they were employed among the moulders.

Mr. Lucas pointed out that it was indirect labour. It would not be any one job, but would cover for the whole of the foundry. It could not be charged to direct labour.

Mr. T. Spiers raised the question with regard to patterns that were sent to the foundries by customers in rather a poor condition, and asked whether Mr. Lucas thought that the patterns should be made good by the foundry.

In reply, Mr. Lucas agreed that when a foundry was using a customer's patterns they might probably get knocked about, and if they were broken then he considered it was the duty of the foundries to repair them.

Mr. H. J. S. Hilton, in asking how Mr. Lucas would apply on-costs, said that personally he would take it on the percentage of the moulding and core-making, excepting the metal, of course, which would be charged by itself. To-day there appeared to be so many variations on that point.

Mr. Lucas said that some foundries based it on total wages paid to core makers, and some based it on the total weight of good castings produced. Some foundries found their on-costs and divided it into the total weight of good castings, but, of course, much depended, more or less, on the kind of work they were engaged upon. The work might be heavy or light, but it might be advisable to take heavy and light castings separately and add on-costs on either.

Mr. Hilton declared that it would be an improvement for the foundry industry if some unified system could be adopted whereby the foundries could all work on the same basis with regard to costing.

Mr. Bigg asked whether it was proposed to base on-cost as percentage on the cost of the job, on the metal or on the labour?

Mr. Lucas said that if the most of metal was taken separately from the other foundry costs the melting should bear its correct proportion of on-cost, while the moulding and core-making should bear their proportion of on-cost.

A member declared that a labourer, who was handling metal, contributed towards the oncosts, and, when Mr. Lucas replied that, first of all they had got the cost of metal and then the cost of melting, which included labour. Another speaker said that in the majority of cases the cupola labourers did nothing else but attend to the cupola. Why should they not bring it into the cost of metal. For instance, they could take iron at £5 a ton and cost of labour and melting at 12s., and a good casting percentage that was, say, 70 per cent., and a loss in melting of 5 per cent., which he considered were four factors they had got to deal with at the spout. They could only sell their materials that went into the good castings, and that meant they had got to melt 1¼ cwt. to get 1 cwt. of good castings. With regard to wasters, the way to deal with that, in his opinion, was this: 100 per cent. of good production was 10 tons of castings on which £5 had been spent. But, he added, one does not get 100 per cent. They might get 9 tons of castings which had cost productive labour of 10 tons. On that they must base their overhead charges. The object in casting was to make everything as productive as possible.

Mr. Spiers pointed out that if the normal output was 100 tons per week and trade dropped to 50 tons per week, how is one going to squeeze in the other 50 tons so that overheads will cover the output?

Mr. Hammond said that the subject under discussion was one of exceptional interest. They all had some pride in their own systems, and he was of the opinion that if they should again meet at a special meeting they might, with their combination of ideas, bring about some scheme that would be of advantage to them all. He admitted that he had learned much from the address given by Mr. Lucas, and although he was a man who had many years' experience in costing, he could say that some of it would bear fruit. There was a large variety of work in a foundry, and really he was bound to admit it was bewildering the number of systems—patent and automatic—there were, and one was caused to wonder whether they would ever get one system that could be applicable to all foundries. Unfortunately, however, he was afraid this was not possible.

Material Balance Sheet.

Introducing the coke question, Mr. Hammond asked how would they balance the charge on the fuel with the amount that was debited against them by the counting house. Supposing, for instance, they got 500 tons of coke credited to them each month and the fuel was weighed on all charges, what would they do with the difference?

Mr. Lucas said they were bound to lose a certain amount of coke, and it was a loss that should be charged up to general "overheads."

Mr. F. J. Cree was of the opinion that in view of the fact that they got such a big variation of coke, that a better way was to measure it by volume.

Mr. A. E. Pease said that when coke was wet they got a poorer iron, and it could be attributed to wet coke. He certainly thought that coke should be charged by volume into the cupola. If through some circumstances they only had to run a 30-ton "blow" one day and another day a 60-ton "blow," he had found that the coke varied in the two days. How would they propose to allocate that charge on their melting costs?

Mr. Lucas said it would hardly be fair to take the cost daily. It would be better to take an average cost each month. If they did that he thought they would find that they got a fair result.

Cost of Oil Sand Cores.

Raising the question of oil sand and natural bonded said, Mr. C. Blades said that although he agreed natural bonded sand was an advantage when it could be obtained quite close to the foundry, his experience had been that when oil sand was used for making cores they could put a cheaper class of labour on the job. It was not necessary to get a man who had worked in a foundry for perhaps 30 years to know how to make them.

Mr. Lucas was of opinion that where foundries were so situated that they could get natural bonded sand he could not see what good it was in using the more expensive and then again the cost of transport of sea sand to inland foundries was rather high.

Mr. W. Hammond emphasised the advisability of making a pattern as simple as possible. To-day there was a dearth of skilled moulders, and, that being so, they had to consider when putting a pattern on a plate to put it on in the simplest possible way so that they might utilise unskilled labour.

Mr. Lucas said it was a common practice and a failing on the part of a good many pattern-makers when making a pattern for a machine mould, to introduce, what he would term excessive core-making. One does not, as a general rule, put unskilled labour on moulding machines; a man who works such a machine is more or less of a semi-skilled type. He thought Mr. Hammond's point rather fell to the ground. If they were going to lessen the work on the machines and increase the work of their core-making, he failed to see where there was to be any saving. His point was that more care and thought should be taken in the making of patterns so that core-making would be to a certain extent eliminated as much as possible.

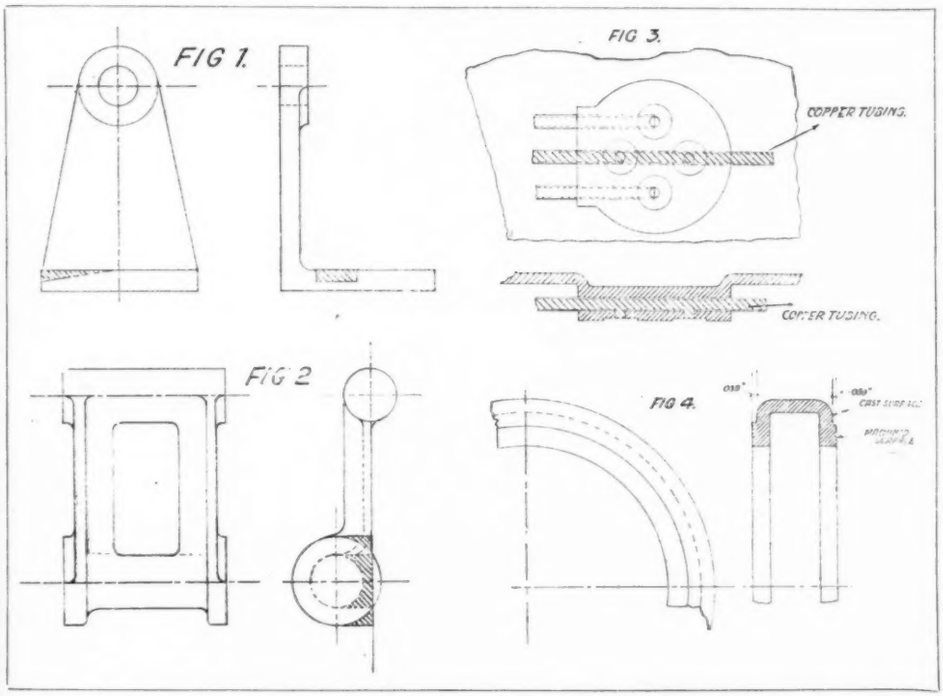
On the proposition of Mr. W. Hammond, seconded by Mr. C. W. Bigg, a hearty vote of thanks was accorded Mr. Lucas for his very interesting and instructive address.

Death of a Scottish Ironfounder.—Mr. Alexander Whitson died at his Glasgow residence on November 2. He had over sixty years' association with the iron trade as merchant and manufacturer, and was at one time a director of the British Hydraulic Foundry Co. at Whiteinch. At the time of his death he was chairman and director of the Lion Foundry Company, Kirkintilloch. Mr. Whitson was interested in many social, religious and charitable organisations, and served for a number of years as a member of the Glasgow City Council.

Design and Patternmaking in Relation to Efficient Production of Castings.*

By John R. Wilson (Surtees Gold Medallist).

The design of a piece has a most important bearing on the efficient production of castings. Its simplicity or intricacy directly affects the type of mould which will be made and the manner in which it will be filled as well as the type and kind of pattern which will be used in making the mould. The pattern and the mould are inseparably bound up in each other, and what affects the one usually affects the other. It is a common occurrence to hear moulders blaming the design of a piece as the source of many of their troubles. In many cases this may be true. It should not be forgotten, however, that the designer is often tied up by the requirements of the finished product, so that what appears as requiring a simple modification in design could not be permitted. There are occasions, nevertheless, when the designer, by a simple alteration could simplify matters both for the patternmaker and also for the moulder. Sometimes it is not a question of design at all, but the lack of a complete understanding of moulding on the part of the patternmaker which causes the trouble. These points would suggest that the ideal arrangement for the efficient production of castings would be obtained when the designer possessed full and complete information as to patternmaking and moulding. This, of course, is more or less impossible, but the results of such a condition could be very closely reached by closer association and free discussion between the designer and those responsible for the pattern and the casting.



Designers.

The purpose for which a piece is to be used comes first and foremost in the design. This involves a consideration of the kind of material which will be used in making it, whether it will be made from stock, stamping, forging, or casting. If a casting is decided upon the designer must study the question as to whether the casting is easy, difficult, or even impossible, to make. This will involve the consideration of a number of points which intimately affect efficiency and economy in the foundry. The design must allow for a suitable line for parting, and it must provide for the draw in the mould. Where a piece could be cored the cost of coring must be weighed against what it would cost to machine the hole from the solid metal. Such smaller points must also be considered as spot facing the metal round the hole for the head of a nut or bolt, instead of having a machined boss entailing the use of a loose piece in making the boss in a mould. The walls of the piece should be as uniform in thickness as the design will permit, and ample fillets should be provided on inside corners, etc. Most important too, is the question, have all reasonable precautions been taken to avoid distortion, due to stresses caused while cooling, or will an additional web or slight modification in shape require to be made? Many of these points can be decided by the designer only, but in others he should be guided by the foundry where practical experience can put before him slight modifications or corrections in design which will make for efficiency in foundry production.

Designer and Patternmaker in Relation to the Moulder.

Many of the points in design, referred to above as affecting the moulder, also affect the patternmaker. Sometimes the patternmaker is given a problem in wood-working which is well-nigh impossible, or which involves such a number of loose or small parts as to result in great difficulty in making the mould, in loss of time in making it, and in a casting of poor appearance. The patternmaker who knows his job aims at simplicity and stability in his pattern. Once he has decided on the method of making his pattern he should get into touch with the foundry, for many points affecting the moulder can be considered at this stage. The type of pattern will have to be considered in the light of the quantity to be cast. Strength is required to withstand the rapping and withdrawal from the mould. Loose pieces, cores, or drawbacks, all of which influence considerably the cost of moulding should be discussed. The patternmaker must possess a thorough knowledge of moulding for many points have to be taken into account which do not appear on the drawing, such as taper, fillets, and correct jointing to facilitate moulding, and obviating as far as possible unsightly joint marks on the finished casting. Where cores are required the patternmaker can assist the moulder greatly by providing suitable bearing surfaces on points, and by adopting methods of guides which will go to help the correct placing of the cores in the moulds. It is false economy to save wood where core prints are concerned for any extra expense incurred in the patternshop will be more than balanced in the foundry. The part the patternmaker plays in relation to the moulder is obvious. It should also be obvious that many of the problems presented by the designer to the moulder could be eliminated, or at least modified, by discussion between the designer and the patternmaker at this stage.

Examples of Economies Achieved.

Machine plate and plate moulding are big factors in the production of uniform castings. The elimination of rapping increases the life of the pattern. It also gives a clean joint which requires less dressing, and thereby enables the foundry to produce a much better looking casting than would otherwise be obtained if moulded without a plate. It is often the case that a pattern made strictly to drawing cannot be put on a plate. When this has been brought to the notice of the designer it has been found possible in many cases to effect a slight alteration in the design without affecting the service of the piece so as to allow the use of a plate in moulding. Fig. 1 illustrates this point. The drawing as originally made out required the groove (cross hatched) should be cast. The drawing was altered so as to leave this part solid, and have it machine finished instead. This enabled the foundry to deliver to the machine shop a first-class job in a much shorter time than would have been the case had the groove been cast. The casting was free from unsightly joint marks and comparatively little extra expense was incurred in the machine shop. Fig. 2 shows another instance in which the designer can help the foundry by making an alteration in design. As originally drawn, this piece would have been rather inconvenient for plate work, but when the designer included the portions cross hatched, it became a simple plate job. The alteration in no way affecting the efficiency of the finished product. These two examples are only typical of numerous ways in which consultations between designer, patternmaker, and foundryman can lead to a cheaper and better foundry product.

Plate System for Quantity Production.

The designer, of course, can hardly be expected to know all the details of plate moulding which go to facilitate foundry production. A detailed description of a plate method which can be adopted where there is a quantity of castings to be made, or where there is a likelihood of the job being repeated at a later date, will perhaps best illustrate this point. The plate to be used is machined with certain apertures. The patternmaker then makes wooden discs to fit these apertures. A jig or fixture is next used, with an aperture corresponding to the disc and the plate. The wooden disc is placed in the aperture in the jig, and the pattern is fixed in position. If the pattern is halved, one half is fixed on one side of the disc, and the other half on the other side, the latter being easily positioned by taking sizes from the half already fixed and transferring them to the other side. There is very little chance of error resulting in the registering of the two halves, and the time taken in setting them is much shorter than under ordinary methods owing to the jig being so easily handled. The disc, with the pattern fixed, is now taken from the jig and transferred to the aperture in the plate and fixed with four screws. A big advantage results from working where there is a variety of patterns requiring a different number of pieces off each. When the quantity of one piece has been made,

* A Paper presented to the Scottish Branch of the Institute of British Foundrymen, Mr. John Longden presiding.

the pattern can be removed from the plate and another inserted in its place without having the entire plate set up again. The jig ensures its correct position on the plate, so that it becomes only a matter of screwing off one and fastening on the other. Another advantage from this system is that should a repeat order come along the work can be started at once, no time and expense being incurred, and accurate results are obtained initially.

Value of Plate Work in Machining.

All plate work requires accurate plating of the patterns on the plate so as to ensure patterns which are halved coming directly in line when moulded, and the box closed. This results in a casting which requires the minimum of dressing and buffing, an essential feature when the castings are to be machined with the aid of jigs and fixtures. Jigs and fixtures (Fig. 5) are made to the finished drawing sizes, plus machining allowances, but no allowance is made for casting irregularities. When it has been decided to use these contrivances, which locate from cast surfaces, the foundry should be informed to that effect, so that a method of casting may be arranged whereby the gate or runner will not interfere with faces from which locations are to be made. The fact that plate moulding produces a very regular and uniform casting makes it particularly suitable for work which is to be jig-machined. Moreover, it is much easier to secure the minimum machining allowance, which is very desirable as far as the machine shop is concerned, because it results in time saving, which means, in the long run, increased factory output.

The Foundry End of the Problem.

Up to this point the onus of improving foundry efficiency has been laid on the designer, but this is not the whole solution to the problem, for the foundry can do much to improve the standard of castings, especially in cases where the designer finds it impossible to allow any modifications or alterations in design. Such cases are frequently cropping up in connection with heavy bosses and abrupt changes of thickness. The foundry can overcome these or at least minimise their bad effects by correct positioning of gates, flows, chills, etc.

Fig. 3 shows a section of a casting which presented great difficulty in casting. It shows a portion having a heavy section into which four holes had to be bored. Two of these holes formed junctions for a water supply, and two for a compressed-air supply. As would be expected in a piece like this, this area of the casting was invariably porous—a serious fault, which could not be tolerated and resulted in the casting being scrapped. In this case the designer came to the rescue of the foundry by inserting copper tubing (shown cross hatched) right through the casting at this heavy section, and thereby preventing the water from coming into direct contact with the casting. This change in design resulted in a great saving in trouble in the foundry, and is a point worth bearing in mind when similar problems arise.

A Faulty Design.

Fig. 4 shows a section of a casting which includes a common mistake made by designers. The designer has only allowed 0.05 in. clearance from the cast surface to the machined surface. Now the pattern requires to be jointed at the centre line shown, and rammed up in halves. This means that each half must be rapped to enable the moulder to withdraw it from the mould. The consequence is, there is a tendency to increase the overall size of the mould and so produce an oversize casting. When the piece is machined to size, it will be found that there is no longer a clearance between the cast surface and the machined surface. If this clearance is essential extra machining will require to be attempted. The piece, in fact, may have to be scrapped if the section of metal is insufficient to allow of any reduction taking place. If the designer cannot allow more clearance, and will not alter the design, he should instruct the pattern-maker so that precautions will be taken when making the pattern to ensure that particular attention will be given to this point, both in the patternshop and in the foundry.

Scientific Foundry Management.

There is a further aspect of this question of how to improve output and quality of work in foundry practice to which greater attention will require to be given in future, especially in those foundries which manufacture a large variety and type of castings. This involves that which is known as scientific management. The old type of foundry foreman was responsible for all branches of the work, including the formulæ for various metal mixtures to be used, methods of moulding and casting, the standard and quality of work which could be turned out and by no means least of all the control of the men working under him, and the keeping of delivery dates. It is obvious that this is more than one man could tackle efficiently, so it is not surprising to find that these duties are being relegated under separate individuals. A metallurgist takes over the metal mixing, a foreman looks after the moulding and casting, and an inspector determines the standard of work which will pass. There is still, however, room for vast improvements, especially in the work left to the foreman. Investigation into the best methods of obtaining results could be made much more systematic. Records could be kept and filed for future reference. Take, for example, the increased demand for aluminium castings for engineering purposes.

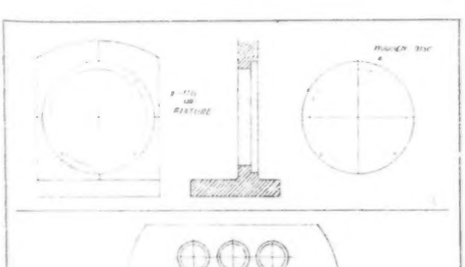


Fig. 5.

This metal presents many new difficulties to the foundry. The position of gates and runners, and chills require special attention. If a quantity of castings are to be made it is advisable first of all to investigate and find out the best possible method of moulding. Having got this a record should be kept showing exactly how the best results were obtained. This record should contain such items as the casting temperature, the rate of pouring, the kind of alloy, etc. A sketch should also be made, showing the position of the gate, chills, flows, etc. Such a record would greatly help production, because, should the job be repeated, the foundry is ready to start production immediately.

The introduction of foundry work into the engineering classes at the Evening Schools should be encouraged, as this would ensure the future designer having the necessary knowledge, which is essential, and plays an important part in the production of efficient castings.

DISCUSSION.

Mr. Russell, opening the discussion which followed, said he was afraid they would not get very much work done if they tried to make a pattern to suit every moulder. On the whole, however, he thought that the pattern-making people were beginning to wake up in regard to the advisability of getting to know a little more about moulding.

Mr. Laurie said that the question must come up in the patternshop—were they making this pattern for their own firm, or for an outside firm? In these commercial times they did not always get what they would like. Then, again, they did not always do the same job in the same way.

Mr. Campion said that they were always being asked by the practical men for a practical Paper. Here was a Paper of an essentially practical nature, and the practical men were reluctant to say even a few words about it.

Mr. John Bell, Hon. Secretary, said it was fairly well known amongst patternmakers that the patternmaker was a convenient man to blame if things went wrong. (Laughter.) Mr. Wilson's problem was one of co-operation, and the difficulty in securing that co-operation was that the different departments were not always under their own control. If they were all under the one management, there was a chance of having a proper system of accountancy. Where they were all under separate control they would never get that. He remembered seeing a good example of that co-operation in Detroit, when he was over in the States. The firm in question had to make 75,000 to 250,000 castings. Six to eight weeks were spent in getting the patterns prepared. Then the first castings were cut up and examined, and there was a conference among the chiefs of the departments. Another pattern was prepared, and then the foundry went right ahead. Co-operation like that was impossible here, but some endeavour should be made to achieve it in the interests of the trade as a whole.

Direct Labour Costs in Cast Iron.

Mr. E. J. Fox, the managing director of the Stanton Ironworks Company, Limited, asks for our comments on a leaflet he has sent us which gives the following data.

One ton of Stanton iron pipes means wages paid in England on "getting" and converting eight tons of material.

It takes 3½ tons of British iron ore, ½ ton of British limestone, and 2 tons of British fuel, namely, 6 tons of British materials, to produce 1 ton of British pig-iron. It takes over 1 ton of British pig-iron to make 1 ton of Stanton pipes. This gives a total of 8 tons, all of which is conveyed on British railways.

Every £100 spent on Stanton pipes means over £75 paid to British workmen, most of which is paid directly by the Stanton Company.

Our mentality is such that the receipt of this information makes us avid for more, and we would quote from an American source that to make a ton of finished castings one must transport 100 tons of material. How many tons are moved in the making of one ton of sand-cast and spun pipes? We are aware that at Stanton many pipes are cast centrifugally, which cuts out the whole of the handling and transport of the mould and core material, but for sand-cast pipe the figure of eight tons is definitely inadequate, as there have been omitted cupola coke, limestone, cupola patching material, moulding and core materials, refractories, moulding boxes, etc. We can, however, state definitely that there has been no overstatement of the case by the Stanton concern.

Steel Castings Conference.

An important series of meetings are being held in Glasgow under the joint auspices of the Scottish branches of the Institute of British Foundrymen and the Institution of Mechanical Engineers with the active co-operation of the Admiralty.

The Engineers' point of view was stated by Engineer-Commander Sedgwick, R.N., and Dr. V. E. Pullin, O.B.E., at the first meeting on November 1. The Producers' point of view was dealt with by Dr. A. McCance and Mr. J. Jefferson, A.R.S.M., at the second meeting on November 10. The Papers will be fully reported in a later number and a general discussion will be commenced at the third meeting to be held on Thursday, December 6. Users and producers of steel castings are invited to be present and take part in the discussion. Particulars of future meetings may be obtained from Mr. Jas. Smith, B.Sc., Royal Technical College, or Mr. John Bell, 60, St. Enoch Sq., Glasgow.

A Symposium on Steel Castings.

ADMIRALTY REQUIREMENTS AND X-RAY INVESTIGATIONS.

This important discussion on the question of steel castings under high temperature and pressure took place at the first of a series of joint meetings of the Institute of Mechanical Engineers and the Scottish Branch of the Institute of British Foundrymen, held at the Royal Technical College on November 1, 1928.

The Chairman (Mr. James Richardson, B.Sc., President of the local section of the Institution of Mechanical Engineers) introduced the principal speakers, Engineer-Commander Sedgwick, R.N., and Dr. Pullin, who received a cordial welcome.

Eng.-Commander Sedgwick said he took it that the common desire was to obtain a final understanding between the founder, the engineer, and the user. The functions of these three important persons were that the user demands and pays the piper, the engineer produced the design, and the founder cast. If the castings were not quite acceptable to the user, either the user's demands were unreasonable or the engineer's designs were not practical, or the founder's technique was wanting. It was the business of the meeting to come to some decision on the subject if they could. He, personally, had an open mind on the question. He was aware that a certain standard had been formulated, and it did not appear to be being met. Whether this standard was too high, perhaps, could be decided; that was his hope. He had been asked to open this discussion in his capacity as representative of one of the largest users of steel castings in this country. He would like to stress that the Admiralty made use, of course, of a large number of steel castings of all descriptions, but on this occasion he proposed to confine himself mainly to those with which he was most conversant; that was to say, those of the highest quality—castings that have to withstand steam, which may be at high temperature and pressure, and those used in machinery.

But the desire to make use of steel castings at all for machinery services was due to two principal causes, which were to some extent interdependent. These were, first, the need for a material to withstand the action of superheated steam, possibly at a very high temperature, about 700 deg. F. (370 deg. C.), and at high pressure; and, secondly, the hope of replacing cast iron by a stronger substitute, thus reducing weight.

Requirements to be Met.

The material suitable for the production of castings to stand up to superheated steam must (*a*) be free from "growth" when exposed to high temperatures; (*b*) possess high strength at elevated temperatures; (*c*) possess the necessary properties for a casting material; and (*d*) be cheap.

There were a number of metals that would meet the first two of these requirements, a variety of alloys, both ferrous and non-ferrous, which were, however, objectionable in varying degrees as regards non-fulfilment of the two final conditions. That was to say, they could neither be cast nor, if they could, they were by no means cheap. Cast steel alone appeared to meet all these needs, and the Admiralty had decided to encourage in every possible way the use of this material, and it was specified to be used to the fullest possible extent for all those castings which might be exposed to the action of superheated steam, as well as for bedplates, engine columns, etc. The relevant specifications were worded so as to require the use of this material to the fullest extent. In requiring the more general use of cast steel, the Admiralty was encouraged by the apparently sound and frequently intricate castings that had been made of this material, not only in this country but also abroad. He particularly stressed "abroad" because he had seen some remarkable foreign castings of fine appearance, but for the internal condition he could not answer. No doubt was felt, however, but that these could be fully equalled, if not surpassed, by British steel foundries.

The increasing use of steel castings for naval purposes, and particularly for parts exposed to high pressure and superheated steam, dated from about 1923, and engineers and founders were probably better aware of the results of that than the speaker. During the succeeding years large sums must have been expended, whilst certainly much anxiety has been experienced, and there had been a great deal of delay in attempting to produce castings which would meet the specified requirements, and which could be accepted for the exacting services demanded of them.

Specification for Machinery Castings.

The Naval requirements for machinery castings were:—(*a*) The designed dimensions must be adhered to throughout the finished article as closely as possible; (*b*) the material must be everywhere homogeneous and of the specified quality, and must be free from internal cavities and cracks; (*c*) the article must be free from porosity; and (*d*) internal stresses must be reasonably absent.

If we could get castings like that, it would be a very fine business indeed. A detailed analysis has been made of the various types of failure that have come to Admiralty notice through the medium of the overseeing branch, but this did not tell the whole tale, for the founders' rejections must aggregate at least as many as those of the overseers, and probably more. The percentage of rejects in the best practice had been as low as 3 per cent. of the number put forward for inspection; in other cases the rejects might be 10 per cent. or even more. It was evident, however, that a small percentage of rejects might none the less be accompanied by appreciable departures from the designed thickness; this latter point could in general be investigated by the overseer, but might none the less lead to undesirable increases in weight. Many castings that had been accepted showed surface imperfections of an apparently superficial nature. In spite of reassuring statements by the founders that these surface imperfections were but surface imperfections and did not matter, he hoped to illustrate later that so-called "surface imperfections" were certainly not "surface imperfections," and which most certainly did matter. Whether all surface imperfections were like that or not one had no means of ascertaining.

Common Failures.

Dr. Pullin would demonstrate the best means available, namely, the X-ray examination. The suitability of the product and the perfection of the technique cannot be judged entirely by the percentage of rejects made as the result of the existing methods of inspection. The general character of the failures reported were:—(1) Blowholes; (2) draws, generally at flanges or changes of section (very few are known in bosses), etc.; (3) porosity under pressure tests; (4) contraction cracks; (5) sand inclusions; (6) scabbing; and (7) failure on physical tests. The failures on physical tests were comparatively small, and nearly all the troubles were either draws or blow-holes, porosity of some sort or other. General defects, such as shifting of cores, shortage of metal when pouring, cold shortness, etc., were not included in the foregoing, as these were obvious foundry faults and, as such, were not germane to the discussion.

The experience with these castings during the past few years had been none too happy, in many cases it having been found impossible to obtain the desired article in cast steel, so that eventually some other material has had to be employed as a substitute. In other cases the thickness had been increased to such an extent that one might as well have used cast iron. In other instances where the product appeared generally sound (apart from minor imperfections) permission has been granted to employ the welding torch or some other means to render the part available for service.

Danger of Laxity in Patching.

This policy of patching was dictated by the eventual urgency of the situation, but it was realised that such a course involved the acceptance of certain risks, and was in any case inimical to the best interests of the foundry trade and of the Admiralty alike, because if patching is permitted to continue, one was not asking anybody to take much trouble over his casting. It has been frequently stated that undue importance was attached to the soundness of castings destined for parts of naval machinery, and that many of those which were rejected could, subject to a little patching, safely be employed for their intended service. There was, however, another point of view which it is proposed to outline.

Steel castings employed for machinery purposes in H.M. Navy differ from those designed for other uses, in that the former were almost invariably subjected to high temperatures and pressures—the first of these factors reduced the strength of the material, while the second entails entire freedom from porosity; cracks and sponginess not only impaired the steam tightness of the finished article but also gave rise to grave doubts as to its soundness. No responsible person would care to take needless risks with parts the failure of which might cause loss of life and may even endanger the ultimate success of a military operation. That point was so obvious that it was certain to be granted.

Underlying Reasons.

In insisting upon sound castings the engineer-in-chief had, in fact, two main objects in view, namely, maintaining the very high standard of reliability hitherto associated with the machinery of British warships, and, secondly, improving the military qualities of the vessel by reducing the weight of her machinery, which was one of the few ways in which she could enhance her military qualities. Rigid inspection had one further indirect object in view, namely, that of improving the quality of the product, thus enhancing British prestige among the users of machinery all over the world. This was an important service rendered to the manufacturers of the country by those funds of which the Admiralty controlled the expenditure. It was the most important duty put upon the Admiralty to spend the funds not only to produce fine ships but also to help forward the trade of the country, and if one did not do one's best to produce the finest articles that were possible one was failing in one's duty.

The use of the welding torch might possibly be a legitimate method of fairing up prospective jointing surfaces, and was, of course, a valuable aid for removing waster material, but its recognition as a proper tool for any other purposes tend to lower the standard of the product and was detrimental to progress towards perfection of technique. This palliative was open also to the grave objection that, with present methods of inspection, it might be used to cover defects of apparently superficial nature with possibly disastrous results.

[The lecturer here showed a number of slides which revealed defects which were not shown on the surface.]

Hidden Defects Revealed.

Continuing, Commander Sedgwick said that in the cases shown there was no evidence on the surface of any definite cracks, slight markings being all that appeared of the severe internal defects subsequently discovered by means of X-rays. These particular castings would have been passed by any inspector, and it was impossible to say how many parts now on service contained similar defects, which might remain unsuspected till they gave rise to eventual failure. Examination of castings by X-ray and by magnetic methods is being rapidly developed—magnetic methods mostly in the United States. He thought it had not been adopted in this country, but X-rays in Dr. Pullin's hands for some 12 years had been carried on, and he would state the progress achieved was unquestionable. After examining a large number of castings, with the results outlined, there must be instituted a method of inspection to indicate what the internal characteristics were. The general adoption of some such method should do much to remove the present uncertainties in the minds of engineers, and should prove economical by saving the heavy expenses incidental to the removal of defective parts on service.

Present Position of Steel Castings.

The existing position with regard to steel castings was: The requirements, for machinery purposes at least, were that definitely sound, homogeneous castings of the thinnest possible scantlings were desired. He insisted that they were not forthcoming, the founders did not appear to be able to meet the demand. These meetings were held with the object of discovering the reason. The logical alternative reasons were:—

(1) *The designer was asking too much of the founder.* If so, why did not the latter protest instead of wasting time and money in attempting the impossible?

(2) *The standard of soundness set by the Admiralty for this service aimed too high.* That may be, but the user had the right to set his own standard, and if it could not be fulfilled, well he would probably go on to another material and endeavour to obtain his standard fulfilled with that.

(3) *That the founder had not fully explored the possibilities of his art* in this particular direction. This appeared very likely in view of the extreme excellence of some steel castings that were produced both here and abroad. If it could be done in one case, why not in others? He was at the moment having to examine some very fine malleable and steel castings, and this appeared to be borne out very well. They did not come from this country, but he hoped to compare with them a very fine example of British steel casting, because he wished to know whether the foreign steel castings were as good as British, or better. If they were better we should probably find a way to make ours as good. If they were not better, and if the demand existed we should continue with our own as they were.

The technique of the modern chemist and metallurgist was available for the assistance of the practical man, and progress would be needlessly retarded at the cost of eventual economy if these aids were not employed. It has been suggested that founders were too much in the hands of the "rule of thumb" expert, and that modern needs required the adoption of modern methods of control and investigation.

(4) *The product might already be up to the required standard,* as witness the very small percentage of rejects experienced in some cases.

In the face of the difficulties that had sometimes been met in producing sound castings at all, and in view of the unsuspected weaknesses sometimes revealed by complete examination of apparently good castings, he did not think this view could be seriously contended. If, however, it was true that the required standard was regularly attained, then the user's next step was to ask for thinner castings—and he doubted if one would get them under the existing conditions, save at prohibitive expenditure of time and money.

All that was required from the user's point of view was definite evidence regarding the practical limitations which determine the minimum thickness of reliable steel castings suitable for a given purpose. Give that information to the designer and he would then know where he was. It was a very simple matter. Nobody was asking for the impossible. The Admiralty did want the thinnest castings made of steel that the founder could give them, and it was up to the latter to tell us what was the thinnest castings they could produce.

More Co-operation Needed.

A critical examination of the existing situation led one to the opinion that a far better liaison between the foundry and the user, through the intermediary of the designer, was probably the main ingredient of success in this matter. He suggested that the founder and the designer were often unacquainted, and this was often due to the complicated chain of persons between them, the designs frequently being greatly modified after they had left their originator. It was too often the case that foundries accept work known to be almost impossible to carry out in a satisfactory manner; if one foundry did not take the job, then a rival one would, but in either case the waste of time, fuel, material and money appeared to be appalling. Co-operation undoubtedly on national lines was going on in other countries, particularly in countries like Germany, and if we were to compete and not have steel castings bought in Germany it looked as though something of that sort would have to happen. It was to the general interest to get the very best casting. In the existing state of commercial rivalry between firms it was difficult to suggest any remedy, and if a solution was to be found it would appear to lie in co-operation on more national lines, using every available modern method of investigation to ensure that the fundamental laws underlying the casting operation were really known.

The products of the foundry trade in this country are often of unsurpassed quality, but no one would deny that this fine standard was by no means invariable. Modern demands were becoming more and more exacting, and the rapid rate of advance of the past century could now be expected; instead, every new step will be made with increasing difficulty and the cost was likely to be more than comparatively small organisations can meet.

In conclusion the speaker pointed out that this matter was worthy of pursuit quite apart from naval requirements. The steam engine could only hope to compete effectively with the internal combustion engine by employing steam at the highest possible temperature and the steel casting was about the only material that one can use for casting in the same line at a reasonable price, so that if a sound steel casting can be produced there was no question about the demand. Further than that the oil engine itself was likely to require such castings in order to reduce weight so that between the two it appeared as though the founder was in a very happy position. Finally, the user required the thinnest casting possible, and he hoped this meeting would provide evidence as to what were the thinnest castings procurable or what other things the user must not ask the founder to produce. Dr. Pullin would probably enlarge on the question of examination of castings, and would amplify what he had said about how he found these surface markings covering very grave defects.

The Chairman, in calling upon Dr. Pullin to explain the latest method of investigation on behalf of the engineer to see that his wishes were being fully carried out, said he had been fortunate enough to have had the opportunity of seeing at Woolwich Arsenal this X-ray process under working conditions, and whilst one's first thought was one of sympathy with the steel founder whose products were being submitted to the searching examination of the powerful X-rays, yet, probably, in the long run, nothing was ever to be gained by hiding the truth and, hearing the result of Dr. Pullin's unique investigations on this subject, the gathering would agree that the truth could not be hidden under this system.

X-RAY EXAMINATION OF STEEL CASTINGS.

Dr. Pullin thought Commander Sedgwick had adequately outlined the Admiralty's need, and he proposed to indicate how the Admiralty and the War Office and the Air Force proposed to examine requirements, or existing supplies. He proposed to indicate what can be done, what their present limits were, what they hoped they would be able to do and what they thought their ultimate practical limits were.

Technical Details of X-Ray Work.

X-rays are merely a part of the radiation of a spectrum, and they were the same exactly in nature as ordinary light, but they had a wavelength which was very much less, the average being about 10,000 times shorter than the wavelength of ordinary light. Owing to that particular property they could penetrate materials which were opaque to ordinary light. The question of technique arose, and that precluded very largely the practicability of the use of X-rays. X-rays were absorbed by opaque materials, according to the ordinary exponential equation. $I = I'e^{-\mu x}$. The opacity of the material by X-rays was merely defined by its place in the atomic table. Thus, bones were more opaque than flesh, iron was more opaque than wood and brass was more opaque than iron. In the laboratory the penetrative power of X-rays depended upon the shortness of the wave-length or the frequency of radiation, which depended practically upon the voltage which one was able to apply to the terminals of the X-ray tube.

Limiting Conditions.

At the present time one was not able, under the best possible conditions, to produce X-rays at a voltage higher than 300,000. It has been stated that in America, in California, they produced X-rays at 1,000,000 volts. He saw that in the paper and he wrote to the gentleman who did it to tell him how he did it, but he had had no reply yet. (Laughter.) But in England, at any rate, X-rays cannot be produced at any higher voltage than 300,000, and one cannot do that very long because the X-ray tube broke. Such voltage exists, of course, but there were experimental difficulties in the way of producing an X-ray tube that would stand a higher voltage than that. That was part of his research. With a voltage, however, of 300,000, and with suitable technical precautions one could penetrate five inches of mild steel and could reveal a cavity in it which was about 3 per cent. of its thickness; this, however, was not applicable in the workshop. One was dealing with a set of conditions there that were essentially laboratory conditions. So far as the speaker had been able to accomplish practical examination of metals, one could extend the voltage more than about 220,000 volts. But that gave a practical penetration of three inches of mild steel and, again, enabled one to see a flaw of about 3 per cent. of the thickness of the material. Experimental evidence went to show that as one increased in voltage one would be able to penetrate thicker metals up to 7 or 8 in. thick. Those figures embraced materials of considerable importance to the services. For example, tubes of guns and certain other forgings that did sometimes contain flaws, although one was told forgings did not.

The Phenomenon of Scattering.

It should not be imagined that one could just bring up the X-ray tube, place the casting in it and press a button and take a picture as one would with a Kodak. One could, because of the phenomenon, which always occurs when penetrating opaque materials with X-rays, namely scattering. It was very similar to the phenomenon of scattering ordinary light through a fog and, unfortunately, with X-rays, when the scattering radiation from the surface, was atomic, it affected the photographic plate so that if one increased the scattering very much, as one did with short radiations, one so fogged the plate that one was liable to do away with any useful contrast. The methods adopted to eliminate this scattering and creeping radiation, constituted one of the great difficulties in this work, particularly when dealing with irregularly-shaped castings which had to be dealt with by this method so as to be of practical utility.

[The speaker here projected a number of slides and explained the methods of investigation.]

De-sensitised Films Used.

One was very often asked whether visual X-ray examination of steel castings was possible. The answer to that is that for very thin materials, materials up to ½ in. in thickness, visual examination for fine cracks and flaws and cavities was possible and practicable. For thicknesses over ½ in. under practical conditions it is not possible. The reason for that was obvious. If one was using the fluorescent screen method of visual examination the action of the rays, if passing through the specimen, had to be instantaneous, whereas, on a photographic film there was an exposure, and the action of the rays passing through the specimen was cumulative. The speaker doubted whether one would be able to increase visual inspection of materials beyond 1 in., but thought in a short time it would be practicable to examine steel materials of 1 in. in thickness visually without any necessity for photography. Another difficulty was that of producing or finding an X-ray dark room in a factory. There had been done a great deal of work on the de-sensitisation of films, and they now used films which had been de-sensitised to ordinary light, whilst at the same time retaining their sensitivity to X-rays. When that was developed a little more they would be able to do photographic work in the factory without any necessity for a dark room.

Practical Consideration.

The next practical question was one of exposure. How long did these exposures take for thick castings? When taking X-ray pictures one always took advantage of the fact that there were certain chemicals which fluoresce under the action of the X-rays. Platino-cyanide, calcium tungstate, and a few other chemical compounds, all fluoresced under the influence of X-rays so that they used in close contact with the X-ray film one of those screens coated with calcium tungstate or one of these other fluorescent materials and that had the effect of reducing the normal X-ray exposure some 30 or 40 times, so that the actual exposure for, say, 2-in. steel need not be more than 2 or 3 mins., with the proper equipment. That gave a rough idea of what sort of time an X-ray exposure ought to take. Of course, it was not true for the very thick ones—the exposure was very much higher—but for practical conditions such as has been outlined the normal exposure was anything up to five minutes and very rarely any more.

[The speaker here projected a further series of slides.]

X-Rays to Aid Co-operation.

The radiography of specimens by X-ray had now reached the stage where it could be applied practically in the factory, yet he felt that the real use of X-rays from the point of view of the foundry would be not so much as a routine inspection, but in his experience, where it would be useful was when a batch of castings was to be produced, the very first of these should be X-rayed immediately and the foundryman should see the X-ray picture and have it explained to him, and if he saw where the faults were and knew what sort of faults they were, the probability was that while it was fresh in his mind he would be able to modify his technique so that he would get better results. When they had this X-ray examination the designer should be there also to see what the practical effect on his design was. It was there that X-rays would really justify their use. The immediate examination of castings by X-ray had often enabled a foundryman to correct mistakes and immediately to produce good castings.

X-Ray Crystal Analysis and Strain Removal.

By using X-rays in another way one was able to see how the atoms of the atomic lattices in metal were ranged and oriented. Now atomic orientation in metal was strain, and he would like to be a bit prophetic at this point. He could examine a casting by one of the methods of crystal analysis and could determine the orientation of the atoms. In other words one could see if strain was present. It could be annealed and a second X-ray crystal analysis picture taken, and then one could state whether the strain had vanished, partly vanished, or whether it was still there. Now it was rather early to speak of these experiments, but some of the results were positively amazing. He thought that the foundryman had no idea as to the value of annealing, until it was shown by X-ray. In the future X-rays would probably be used to examine new designs of castings, and then one would be able to say to the designer perhaps "That would not do; there was too much strain in this part," or, "This was a specially weak part in the casting, and it was liable to break or crack ultimately." We were also placed in a position to state to the annealer, "Your annealing which you said was so efficient, might just as well be done in cold water." That sounded exaggerated, but it was not quite so exaggerated after all.

DISCUSSION.

MR. GEORGE NESS said it was rather difficult to discuss the addresses presented, because to him they had come largely as a revelation. He was not a steel foundryman, and his experiences up to then had been very largely with smaller types of castings, probably steam ends of turbines, valves for carrying superheated steam, but not highly superheated steam, not steam at high pressure with high superheating but what he regarded as good average modern practice in land work particularly. There had been a great deal of common sense in what Commander Sedgwick said with regard to the requirements and to the acting of the steel foundrymen in co-operation with the designer. After seeing the X-ray photographs he felt very largely that any ammunition he had prepared had disappeared, for the simple reason that these X-ray photographs have exhibited definite weaknesses which could not have been really apprehended by ordinary visual examination. Up till then he thought one had been very largely guided in inspection work by visual examination, accompanied, where possible, by ordinary testing methods. His experience in connection with works where he was once a director was that he found that the percentage of rejects so far as he was actually concerned was very small. They had a large number of rather smaller castings made on the Continent, and found that they were excellent, but they were all more or less done by the electrical process. These castings might have been slightly superior to the British castings, but latterly we found that the British castings were becoming almost equally good, and, what was more to the point, we bought them as cheaply as they were getting them from the Continent. With regard to the larger castings he did not know so much about the English castings because his works were in Scotland. He had had nothing but splendid material. He had occasionally found a blowhole or two, but very slight. In testing valves, for instance, he regularly applied the paraffin test, anywhere from 1,000 lbs. to 1,500 lbs. to the square inch, and it was a remarkable thing that under the searching effects of paraffin at that high pressure he had a very very small percentage indeed of rejects. It was a peculiar fact, of course, that one did get slight failures under that test where the skin of the casting was broken. That was to say, where one had to subject it to machining, and it was somewhat difficult probably in these castings to trace the course of the leakage; the external leakage might be very far away from the internal defect. He wished to record that in these castings which he had had to deal with they had been excellent, and the rejects had been almost at a minimum, whilst the price was practically the same as those obtained from the Continent. The X-ray photographs shown gave an insight into the latent unsuspected defects. But he could see very great difficulty in applying some of these tests to many of the current engineering subjects. The possibility of applying them to welding is one that might be approached with some considerable success, particularly where the plates were somewhat thin, and if there were available testing set of a light portable nature, suitable for plates up to threequarters or one inch, it might be a very great advantage. Somebody recently asked the speaker if he would like to examine a boiler by means of an X-ray, but he thought even the most ardent boiler inspector would shrink from such a duty. He expressed his thanks to both Commander Sedgwick and Dr. Pullin for the excellent way they had outlined their case, and citizens of this great Empire regard the British Admiralty as having an all-seeing eye and being an omniscient body.

Vote of Thanks.

DR. M'CANCE said Commander Sedgwick had disclosed what might be termed the official view of the ideal steel casting, and he felt that the foundry section, at any rate, had the matter not been handled so tactfully, would have been plunged into the depths of gloom. The Commander had also disclosed what is equally important, that is, the official policy with regard to the attainment of this ideal casting, and he thought they could understand and realise now that what on many occasions had seemed like cruelty had really been motived by the most gentle and sympathetic desire to improve, and to improve not only the founders, but the whole British industry and the prestige of the British industry. Dr. Pullin had been extremely interesting, and in his short lecture had given the result of many years of hard work and hard thought, and he thought everybody would join him now in according the lecturers their heartfelt thanks for giving the product of many years' thought and hard work.

THE CHAIRMAN said that both the members of the Institute of Foundrymen and of the Mechanical Engineers appreciated Dr. M'Cance's remarks to the full. They also appreciated the honour to their respective institutions by having as guests authorities on two such important aspects of the question which we jointly had set out to investigate and explore. This was the first meeting of the series, and at the next meeting two Papers, "Metallurgical Progress," by Dr. M'Cance, and "Steel Castings from the Moulder's Point of View," by Mr. J. Jefferson, will be presented. He was speaking on behalf of the foundrymen as well as on behalf of the mechanical engineers when, for that occasion, he extended to Commander Sedgwick and Dr. Pullin a hearty invitation to join them again, and he certainly hoped that they will be able to be present.

A Note on Safety First in the Ironworks.

BY FRED. GROVE-PALMER, A.I.C.

In studying some statistics of the injuries, both fatal and less serious, received by workers in iron foundries and works generally, it is very interesting to note that contrary to what might, perhaps, have been expected at a first glance, the newly-arrived operatives in the various departments concerned suffered to a smaller extent than did the older and more experienced hands. The reason for this is not far to seek when the matter is investigated: the freshly taken on men are very much more likely to take care of themselves in the presence of the unfamiliar machinery of which they stand in considerable awe, than are the old stagers, who involuntarily uphold the principle that "Familiarity breeds Contempt"; consequently they grow careless as time goes on, and so inevitably come to grief.

By analysing and classifying some figures concerning such accidents the following results, expressed in closely approximate percentages, were found:—

LENGTH OF SERVICE.	PERCENTAGE OF TOTAL ACCIDENTS.
One year or over	66
Six months to one year	13
Three to six months	11
Less than three months	10

It was shown that a comparatively large proportion of those who are included in the first category had been employed in the departments in which they met with the accidents for several years, while amongst those who are included in the last class there are numbers who had been working in other parts of the works prior to their transference to that in which they received the injuries.

It is conclusively evident from the table given above that it is a matter of very grave importance to keep the "Safety First" warnings prominently in the minds of the older workers in every department of the works, as well as in the case of the newcomers, and for this purpose it will be all to the good of the firm, for the owners and the workers alike, if some plan be adopted for ensuring that the operatives are never allowed to reach a stage when they become accustomed to seeing the warnings hang about, or of forgetting what they are there for to such an extent that the original importance of them is disregarded and their presence is scarcely observed.

Luther's Connections with Ironfounding.

According to an Exchange message Martin Luther's father was not a poor miner, but a well-to-do foundry owner. That is stated by Dr. Heinhold, managing director of the Mansfeld Company, who declares that the foundry in question was on the site of the present Mansfeld works. The evidence on which this is based dates back to the year 1502. When the father of the Reformer died, he left a fortune of ten thousand thaler (£1,500), a not inconsiderable sum in those days.

Institute of British Foundrymen.

PRESIDENTIAL ADDRESS TO THE SCOTTISH BRANCH.

The first meeting of the Scottish Branch for the season was held in the Royal Technical College, Glasgow. Mr. Tom Bell, the retiring President, occupied the chair, and at the outset called upon Mr. Campion to present the Oliver Stubbs Gold Medal for 1928 to Dr. Donaldson.

Presentation of Oliver Stubbs Medal.

Mr. Campion, in making the presentation, said that the announcement of the award to one of its members was received with the liveliest satisfaction by the Scottish Branch. Unfortunately ill-health prevented Dr. Donaldson from making the journey to Leicester to receive the medal at the Annual Conference, so that he, as a member of the Awards Committee, had been asked to make the formal award at that meeting.

It gave him more than ordinary pleasure to present the medal, on behalf of the Institute, to one to whom it had been so deservedly awarded. Dr. Donaldson's work in cast iron was well known far beyond the confines of their own Branch, and even of the Institute, for he had attained an international reputation as a metallurgist prosecuting research of far-reaching importance to the foundry and engineering industries.

A week or two after the Leicester meeting the outstanding merit of Dr. Donaldson's work, and the high opinion of it held by the Institute, was confirmed by the University of Edinburgh conferring on him the degree of Doctor of Science for a thesis embodying the results of his researches on cast iron. He was sure they would wish him to take this opportunity of conveying the congratulations of their members to Dr. Donaldson upon what must be described as a remarkable achievement. He called it a remarkable achievement not only because it was probably the first time this degree had been conferred for work on cast iron, but because Edinburgh University was a purely academic institution, and the fact that it had seen fit to confer the doctorate for a thesis dealing entirely with industrial research indicated that the work must have been of exceptional merit.

He had known Dr. Donaldson for a number of years. He was an excellent assistant and an enthusiastic and congenial collaborator in research work, and it was a matter of extreme gratification to him that Dr. Donaldson should receive the highest honour which it was within the power of the Institute to bestow. He congratulated Dr. Donaldson upon the work he had so far accomplished, and trusted that he might have health and strength to continue his researches for many years to come, and that that was but the forerunner of many other honours. (Applause.)

Dr. Donaldson, in reply, said that he had been disappointed at not being able to travel up to England for the presentation of the medal, but that disappointment had disappeared in the fact that the medal had now been presented to him among "his ain folk," by Mr. Campion, who had given him his first tuition in metallurgy, and his first introduction to research work. He would like to express his thanks to the Council of the Scottish Branch for putting his name forward, and to the Institute for the great honour they had done him.

Mr. Tom Bell then introduced Mr. John Longden, the new President of the Branch. Mr. Longden, in his presidential address, said:—

PRESIDENTIAL ADDRESS.

Mr. Bell and Gentlemen,—It is no mean honour to be allowed, for a period, to preside over the activities of such a Branch; a Branch which can be truthfully said to have few peers. Whilst it is true to say, of course, that the part is not greater than the whole, or that the activities and accomplishments of any Branch of the Institute can be regarded as anything more than part of the work of the parent Institute, yet it is important to realise that much the greater part of the contact (in some cases the only contact) of the members with the Institute is through one or other of its Branches. It is this which gives the work of the Branches its importance, and too much thought cannot be given to the problem of how to make that work interesting and helpful to the wide circle of members. That circle is wide in more senses than that of number; it is wide in the richness and variety of the occupational and intellectual types which are to be found on its roll of membership. It includes the university don and his students, the metallurgical chemist, the engineer, the draughtsman, the accountant, the patternmaker and the moulder, together with those in related supervisory positions.

Interrelationship of Knowledge.

To find a subject, or series of subjects, which shall be of interest to such widely varying types would seem, on the face of it, difficult of accomplishment. That object is achieved with considerable success. The reason is not far to seek. All knowledge is related, ultimately, but all metallurgical knowledge is immediately and closely related. Foundry problems are many sided, and often difficult of solution. Solutions, when found, are frequently the cumulative result of the co-operative effort of the chemist, designer, patternmaker, and foundryman.

Probably the Institute is unique in the variety of its professional types, but anyone having understanding of the nature of foundry work will realise that we cannot, if the Institute is to reach its fullest usefulness, afford that any one of those types shall forsake it. The qualification for membership is simply an occupational or professional one, and such a qualification has hitherto proved very satisfactory. There has recently been some discussion of the desirability of setting up a membership qualification of an educational character—though perhaps not a difficult one. I do not here intend to enter into the merits of that question, except to point out that any steps which might tend to exclude the operative moulder from membership would seriously narrow the sphere of usefulness of the Institute.

The Institute is, or should be, a fellowship of all those who are, directly or indirectly, engaged in the production of castings; a fellowship in which we all meet on a basis of equality—an equality based on the policy of "give and take" in the search for the truths underlying our daily work, and a common interest in the advancement of the industry as a whole.

Credit Given for Written Knowledge.

Very largely, the work of the Institute consists of the reading and discussion of Papers. On the theoretical or academic side there is no great difficulty in securing the services of highly competent men to lecture to the Institute or to its Branches, but it is very difficult indeed to induce more than a few of the men who are actually engaged in practical moulding or patternmaking operations to state their views and experience in the form of a Paper. If one would learn what is known of metallurgy, in any of its departments, the literature of that science is at hand. Any man who is possessed of a certain fundamental mental equipment may find out almost everything which has been discovered, or is being investigated, in respect of the behaviour or the nature of metals or of the processes in use. Not only so, but many of our leading research workers have deliberately set themselves out to make the fundamental principles of metallurgy understood by the man in the workshop. A case in point is the Presidential Address which Dr. Rosenhain gave to the Spring Meeting of the Institute of Metals. No doubt his immediate audience was surprised at the nature of the Address, yet I think that he had in mind, not so much the members of the Institute of Metals, as the average foundryman. The Address was a fine introduction to the theoretical aspects of the behaviour of metals when cooling from the liquid state, and showed very clearly the need for the foundryman to secure an understanding of what is sometimes called the "jargon of the scientist." Some of the members of our own Institute have done valuable work in the same direction.

The point I wish to emphasise, however, is that the work done by the chemist is always accompanied by the making of careful records, and these records, together with any deductions which may be drawn from an examination of them, may become available ultimately to anyone who can read—with an understanding of the terms used. Further, any considerable step in discovery is credited to the man who made it.

Unwritten Practical Knowledge.

The production of a casting, however, is primarily the work of the moulder. Moulding is a difficult art, though some branches of it are relatively easy to learn. In the more difficult branches of the work, a thousand-and-one pitfalls lie before the unwary moulder. There are few crafts which call for the exercise of such good judgment, skill and foresight on the craftsman's part. Yet it is doubtful if anywhere he can find a comprehensive statement of the principles into which he must be grounded if he is to become a first-class moulder. One may find sketchy outlines of the principles of moulding here and there in text-books, or in Papers, outlining the making of certain classes of moulds, but nothing more. This body of unwritten principles is an heritage handed down by successive generations of moulders in precept and practice.

The primitive man who first discovered that an axe head could be quickly made by pouring molten copper or bronze into a stone or dried clay mould, thus obviating the laborious work of hammering out a piece of metal to the required shape, was a benefactor to his day and generation. We do not know his name. We do not know that Tubal Cain and Vulcan were deified by primitive races. They are not unsung in modern times. Gounod sings, in his opera, "Irene":—

> "Sons of Tubal Cain, Oh, strong and mighty race;
> Benefactors of man, high and God-like minds,
> In your path thro' the world,
> Ye leave a track of greatness."

The Unknown Inventor of Oil-Sand Cores.

The written history of the craft of moulding in sand for the production of metal castings is almost a blank page. We do not even know whose brain evolved the idea of using an oil bond for silica sand cores. I am of opinion that to that same brain is due a good deal of the success achieved by the modern motor industry, for without the oil-sand core many of the necessary castings would be very difficult and costly, if not impossible, to make.

The modern moulding process is an intricate one. The various methods of venting, by wire or cinders, are not learnt in a day, but only by working side by side with men who have spent a lifetime at the craft, and who themselves learnt it in a similar way. Ramming is an arduous part of the moulder's craft, requiring a good deal of cunning. To know just how hard to ram a mould, to know exactly how near the rammer may approach to a pattern—these things require judgment, based on knowledge. So also do the various methods of reinforcing the mould by means of sprigs, gaggers and irons. The mending-up of a broken part of a mould requires good judgment. I have seen many beautiful moulds, to all appearance, which have produced indifferent or waster castings—much to the dismay of the moulders concerned. Whilst the appearance of a mould counts for something, just as it does in the casting itself, the really important matter is that of how the mould has been made and assembled. The fact is, that each class of mould must be made in line with certain definite principles, allowing little margin for divergence, if complete success is to be attained. The good moulder knows these principles, and always observes them. Other moulders either do not know them all or know them indifferently well.

No Substitute for Long Practice.

These principles can be stated, just as those governing as an alloying or melting process can be stated. Yet nowhere, as I have said, can a really comprehensive statement of the art of moulding be found. It has yet to be written. These

remarks apply, of course, only to that large and important section of the trade which is concerned with heavy or otherwise difficult castings, which require the services of skilled moulders. As we know, there is a large sphere for the production of castings of simple form by the aid of mechanical devices, and which do not call for the employment of skilled moulders in the sense in which I have used the term. Men are trained fairly easily for such work, which calls for little skill on the part of the operator. Though some mechanical aids are coming to the real moulder, the higher branches of the craft require a very high degree of skill and intelligence, a skill and intelligence which are the results of long experience and application.

There does not seem any substitute for long and careful practice of the craft in the rearing of the competent moulder. The training involves a certain muscular development and a certain nervous or mental development. For example, his hands, covered with callosities though they be, are highly sensitive. As he grips a handful of sand he knows at once whether it is of the right moisture content for the particular job he has in hand—he needs no other indicator, however ingenious. As he uses his rammer he knows by the impact exactly when he has rammed enough, and if the sand under his rammer is tight enough for the particular job, or part of the job—for some parts of a job may require different ramming from that of another. When he has drawn his pattern his fingers run over the surface of the mould and tell him where any soft places are much more reliably than any mechanical surface-hardness-testing-meter can. Further, where heavy castings are concerned, surface hardness is not enough; it must be suitably reinforced by equally sound ramming behind it, or deformed or scrap casting may result. It is a pleasure to see him take a portion of sand into his hand and knead or ram it into position to reform a broken part of the mould; to sprig, vent and sleek it. What can be more disappointing than to see a moulder endeavouring to mend up a badly broken pocket of sand in a mould by patting on a series of small portions of sand stuck on the end of his trowel or cleaner, or to see him sleeking fresh pieces of sand on to already sleeked surfaces?

These seem little things, but the foreman who notices it at once places the man who does it in the category of badly-trained moulders. An old moulder with whom I had the privilege to work as a very young apprentice had a radical treatment for such faults. We were finishing the bottom half of a green-sand mould for a machine-tool table when, not being satisfied with the appearance of the already sleeked bottom surface, I put on a bit of sand and endeavoured to sleek it down level. Whilst doing this, I received a smart rap on the knuckles from the old moulder's cleaner, and then received a humiliating lecture on the foolishness of the thing I had done. It is a simple lesson I have never forgotten.

Platitudes and Half-Truths.

In my time in the foundry I have heard expressed by moulders a good many profound truths, some half-truths, and some which were much less than half-truths. For example: it is sometimes said that every gagger, sprig or iron is a vent; the notion being based apparently upon the observed fact that when a mould is cast, gases can be seen burning off in the region of a gagger in a top-part. There is possibly a little truth in the notion. When I was serving my time in a Manchester jobbing shop, a moulder had the courage (I say nothing about his wisdom) to carry the notion to its logical conclusion. He had only been working in the shop about a week when he was given a soleplate to make. The casting was about 8 ft. long by 5 ft. broad, the hollow interior, about 6 in. deep, being lifted in the top-part. The bottom, as cast, was all plate. The pattern was bedded in the floor, over a cinder bed. In bedding in the pattern he did not adopt the ordinary course of venting strongly to the cinder bed with a 5/16 in. vent wire, followed by needle-wiring of the face. Instead, he drove a series of straight ⅜-in. irons down through the cinder bed, leaving their tops a little under the mould face. Like most of the work in that foundry, the mould was cast green. The casting was later lifted out of the floor. All the straight irons came up with it, firmly and permanently a part of it, looking like "the quills of the fretful porcupine." The bottom face of the casting had scabbed from end to end. This, of course, is an extreme case, but it shows the folly of reliance on less than half-truths. If a mould needs venting it should be vented. If it needs ironing it should be ironed. The two functions cannot be combined.

Though these points are commonplace to the really capable moulder, there are many men practising the craft whose understanding of fundamental moulding principles is far from complete. Perhaps they are not to blame. Very few moulders can be said to have had really good all-round training. A man may have served his apprenticeship at a place where the only work on which he could try his hand is of a fairly simple character. He may spend some further years in another shop in which no necessity arises for a high degree of skill. Sooner or later, however, he will find himself in a foundry in which his previous experience has left him quite unfitted for the work he is called upon to do. There is a good deal of specialisation in a foundry which perhaps never contained a moulding machine. If a foreman has a man who has shown himself successful with a particular job, or class of job, he feels disinclined to take him away from it. The result is that other men do not get an opportunity to master the difficulties of that particular job. No foreman would dream of giving a heavy and intricate job to a man who had hitherto made nothing but light work. So also, a very good heavy dry-sand moulder might be quite at a loss if asked to make relatively small castings in a green sand. The same is true of the loam moulder.

Manipulative Skill.

It is certain, however, that manipulative skill cannot be learnt from books or papers. The apprentice (and the adult moulder, too) acquires his knowledge as the result of careful observation of cause and effect, and by precept and practice. There is no doubt, on the other hand, that a good deal of real knowledge, of use to the moulder in his daily work, can be acquired through the spoken or written word. It is for this reason that I suggest that the great body of principles which govern the moulder's craft (leaving aside for the moment metallurgical considerations) should be written up by those best qualified to state them; viz., the moulder. In using the term "moulder" I mean, of course, those men who have been trained and practised as moulders, and also those who have graduated to supervisory positions in that craft.

Widening Pools of Knowledge.

There unfortunately exists, as has been noted, a great reluctance on the part of moulders to say, in the form of papers, or in discussion, what their experience has taught them, with the result that certain pools, say, of knowledge have a less wide use than they should have. There are several reasons for this, perhaps the most important of which is that most moulders are unaccustomed, unlike the professional man, to the presentation of their ideas in this way. It is not that the professional man or research worker is necessarily more intelligent than the moulder. As Prof. Myers, the eminent psychologist, has recently said: "Intelligence is not mere knowledge or attainments, nor is it merely the capacity for following a long chain of abstract reasoning. It is displayed in the skilful manipulation of tools as well as in mathematics, essay writing and other scholastic pursuits. Some highly intelligent people may be unable to employ their powers of intelligence in relation to words or other symbols. Theirs may be a 'practical' or 'concrete' intelligence which enables them to deal effectively with 'things.'" I once heard the late Dr. Lester Ward say that what the world needed was not so much the acquisition of new knowledge, as that as much as possible of existing positive science should be got into the heads of as many people as possible. This aged philosopher had in mind the problems of politics and economics, but whatever is true of those problems is equally true of industrial and technical problems. Taking our own particular case, that of foundry problems, it is obvious that there exists, somewhere, in some form, enough information about almost every branch of work to enable first-class castings to be produced economically. If the problem is a moulding problem, one may be sure that somebody, if one could lay hands on him, has the solution to that problem. The difficulty is to get at him. If the difficulty is a metallurgical one, there is to the hand of the inquirer an immense fund of information due to the activities of the world's research workers, which one can make his own without even the necessity of expressing thanks, if he is possessed of an ability to understand the terms used. I do not suggest that there is no further need for research work in our industry; the contrary is true. Every foundryman realises the complexity of the problems with which he has to deal, and he knows that it is to the trained research worker that he must largely look, if not for their actual solution, then for a rational statement of the cause and cure in the form of an exact and understandable statement. What I do suggest is the need for the round table, and the will to throw ideas into the common fund.

"Rule-of-Thumb" Law Inadequate.

The problem of how to produce a casting may be many-sided, concerning other men than the moulder. Each of them looks at the problem from his own point of view, but none of these views is capable of being kept in a watertight compartment. One sometimes notices, in discussions, an implied suggestion that the "cobbler should stick to his last." That is a mistake. Certainly a man should be master of his own branch of work, but the moulder who understands the physical and chemical principles governing foundry phenomena cannot be otherwise than a better moulder. The chemist who can visualise the various stages and conditions undergone by a casting as it comes into being in the foundry is a better chemist; and the same reasoning applies to the designer and patternmaker.

Foundrymen are frequently charged with working by "rule-of-thumb" methods. A good deal of foundry knowledge is purely empirical in character, and is quite satisfactory for given conditions. There is an immense amount of work to do before the foundryman may find all his data classified into exact science. To take the product of the cupola, cast iron, the wisest knows relatively little about it; yet, every day, good and serviceable castings are being turned out in large quantities. Even with the help of a competent chemist, one can only hope to work to certain useful approximations. On the other hand it is quite true to say that the only real knowledge we have of cast iron is the work of the chemist and physicist. Without an acquaintance with the equilibrium diagram of the iron-carbon series one can hardly begin to think on the subject of the nature of cast iron. The invaluable work of Turner, Stead and other workers has shown with particular brilliance and influence of this, that or the other element; but the magnitude of the problem of weighing the possible interactions of all the elements in an ordinary foundry iron is frankly admitted to be huge, and a very long way from complete solution. Nevertheless the alert foundryman endeavours to bring his every-day practice into line with the march of discovery, by an intelligent use of such data as is available.

All this but shows the necessity which remains for exploration of the only partly-known field of metallurgy. In this work most of us can help: the laboratory worker, with his analysis and microscope, and the foundry worker with careful observation of the large-scale phenomena which appear under his eye from day to day. It does not matter if the latter is untrained in science, if his observation of appearances is good. Such a man may unwittingly supply the key to a problem which some highly-trained research worker is having sleepless nights about.

Craftsmanship and Science.

This, then, is the field of work in which we are all engaged. It is an honourable field. At the British Association meeting, held in this city last month, Sir William Bragg gave an inspiring address on the subject of Craftsmanship and Science. He reminded us that, in early forms of society, the craftsman, by his work, provided the things which made life possible. In the crafts-

man's brain was the knowledge and imagination, and in his hands the skill. To-day, he said, the craftsman's work is split up: inventors, designers and research workers of many kinds now supply the imagination, whilst the skill has mainly become that incidental to that required for the handling of machines. One cannot deny the broad truth of this, yet it is probably less true of founding than of other kinds of craftsmanship. Of course, one must take account of the increasing tendency to simplification and division of labour. The time has been when the moulder studied his pattern and coreboxes, made his own arrangements for venting and lifting, and made the cores and mould himself. Now his cores are, generally, made by a coremaker. He may have his heavier ramming done by a machine. His otherwise difficult and ingenious drawbacks may be blocked out by cores. His cores may be made in oil-sand, thus reducing his venting problem (previously a serious one) to small dimensions. Indeed, the whole of an intricate and important casting may be built up of oil-bound core pieces. One cannot say that the end of this simplification process has been reached. However that may be, there will always remain, whilst castings in metal are used, the need for men who can understand and visualise the process of making a casting as a related whole, as distinct from the making of separate parts of the mould

Sir William Bragg further defines craftsmanship as the skill which is exercised in the production of whatever is wanted for human welfare. That is a new definition, and a fine one. It makes craftsmen of all the members of this Institute, whatever their class of work. It is a title of which no one need to be ashamed.

We may sometimes ask ourselves, To what end is this continued striving for improvement, an improvement which, to be effective, must show itself not only in the opening up of new fields of inquiry, but in the raising of the general level of knowledge? The answer is that, as the great fund of goods and services which is the concrete result of our efforts constitutes what the economist calls the "national dividend," so it is also the fund from which all of us take our respective shares of the things necessary for life and well-being. If that fund is small, the general standard of living cannot be other than low. If it is high, then a higher standard of living is possible. The question as to how wealth, when produced, is distributed, is outside our deliberations as members of this Institute. It has been said that the man who makes two blades of grass grow where only one grew before is a benefactor to his day and generation. It must be equally true that a man who can produce two castings, with the expenditure of no more human and other costs than was required to produce one of the same kind and quality before, is also a benefactor to his day and generation.

We who are engaged in the work of this Institute have another motive, which cannot be expressed in better words than those used by Sir William Bragg in the address referred to above. "There is in men," he says, "more in some, less in others, the natural desire to use what faculties they possess. It is a fact that love of good work and delight in successful accomplishment are powerful motives, and when satisfied are sources of real happiness. Of all the motives that sway the world these are among the purest and best."

Vote of Thanks.

Mr. J. Affleck, in proposing a vote of thanks to Mr. Longden, said that he had covered a very wide ground in his address, and had dealt with some of the most serious problems confronting the industry. Mr. Longden had done well to draw the contrast between craftsmanship and scientific research. He did not think it was sufficiently realised yet how much foundry work was an art, and how much foundries were indebted to the men who could understand and use those little items of detailed knowledge to which he had referred.

Aluminium Plating on Metals.—The successful electro-deposition of aluminium on other metals, recently announced before the American Chemical Society by Prof. D. B. Keyes, of the University of Illinois, is a matter of much interest to the iron and steel trades, more especially to hollow-ware manufacturers and makers of steam-raising equipment.

Steel Castings for Severe Service.

In reply to Sir Robert Hadfield's contribution to the discussion on his Paper,* Mr. John Howe Hall writes:—

As the first makers, and still among the leading producers, of 12 per cent. manganese steel castings in the United States, the author's employers, the Taylor-Wharton Iron and Steel Company, share with their good friend, Sir Robert Hadfield, his pleasure in recalling the days, "now many years ago," when they were assisted by him in developing the manufacture and sale of 12 per cent. manganese steel castings in which they were then, and still are, so signally successful. So, too, they recall with pleasure the success that Sir Robert had in England in the manufacture of cast alloy steels for naval work, such as he illustrates in his discussion.

Despite Sir Robert's statements, however, they know of no instance in which steel castings containing manganese from 1 to 2 per cent. were successfully utilised for their strength and shock-resisting qualities prior to the author's pioneer work at High Bridge in 1909. In the higher carbon ranges, to be sure, these steels were utilised to some extent by Sir Robert Hadfield and others for their hardness, but in 1907, when the author was first associated with his uncle, the late Dr. Henry M. Howe, in the development of special steels for the Taylor-Wharton Iron and Steel Company, he found that steels with manganese averaging 1.50 per cent. were universally considered to be brittle. Dr. Howe, who was at all times in touch with Sir Robert Hadfield in these matters, at that time shared this erroneous view. Indeed, Guillet was the first, to the author's knowledge, to recognise the falsity of this then universally held opinion. The following quotation from Guillet† makes this clear, and shows that to him belongs the credit for first recognising the great possibilities of the pearlitic and sorbitic manganese steels for resisting shock and fatigue:—

"Of the steels containing about 0.20 per cent. carbon, those of the first class (from 1 to 5 per cent. manganese) possess a tensile strength and an elastic limit which rises slowly with the manganese content, while the extension and contraction of area diminish slightly; these steels show a very great resistance to shock. This point is extremely important, and, to show it clearly, we have broken more than 100 Frémont test pieces. The results obtained contradict absolutely the very widespread opinion among metallurgists that manganese makes steel brittle. We believe we have demonstrated clearly, on the contrary, that manganese makes steel brittle only when it is present in sufficient amount, or better, when the sum of the carbon and manganese is high enough to lead to the production of martensite. As long as the structure is pearlitic, the steel, far from being brittle, is extremely homogeneous and possesses a resistance to shock which one finds only exceptionally in carbon steels."

Sir Robert is in error in supposing that the author referred to the *yield point* of 12 per cent. manganese steel in the figures he gave, 17.8 to 20 tons per sq. in. as the elastic limit of that material. On the contrary, the figures given are for the limit of proportionality, and were based upon a number of tests of cast manganese steel, carefully made with an Olsen strain-gauge type of extensometer, reading to 0.000066 in. In the author's opinion, no well-marked yield point has ever been shown to exist in careful tests of cast 12 per cent. manganese steel. The curves showing tests of manganese steel, in Sir Robert's figures 1 and 3 (which, by the way, are of steel containing 0.88 per cent. C., while normal manganese steel contains some 1.20 per cent. C.), in so far as they show anything, illustrate the fact that permanent set began at a figure of some 10,000 lbs. per sq. in., and that no well-marked yield point occurred. The author's carefully conducted tests show the limit of proportionality of this steel in tension to lie between 16.7 and 21.7 tons per sq. in., while the limit of proportionality in compression is much lower, some 9.4 to 12.8 tons per sq. in. These tests also showed the impossibility of locating a definite yield point in either tension or compression.

Limitations of Manganese Steel.

Sir Robert inadvertently misquotes the author when he puts into his mouth the words "he states that these (the explanations of the work-hardening nature of manganese steel) were not *known, defined* or *understood* until some fifteen or twenty years ago." The author's statement was (and still is) that "only during the last ten years has it been *generally recognised* that heavy pressure or pounding must be associated with the abrasion, if manganese steel castings are to develop their full power of resisting wear." There is an enormous difference betwen having a thing "known, defined and understood" by experts such as Sir Robert Hadfield and Prof. Osmond, and having it "generally recognised." The author is well aware that Prof. Osmond gave the explanations in question, but he is also even better aware that all the makers and users of manganese steel castings, for many years afterward, utterly disregarded the obvious conclusions to be drawn from Osmond's observations, and repeatedly endeavoured, often at great expense and loss to their customers and themselves, to utilise 12 per cent. manganese steel castings for classes of service to which they were quite unsuited. In 1907, sixteen years after the first manganese steel was made in the United States (High Bridge, N.J., October 29, 1892), and while the Taylor-Wharton Company was still working in close co-operation with Sir Robert Hadfield, the author found their recognised and proclaimed policy to be to try 12 per cent. manganese steel first for any type of service involving wear for which it might be proposed. In the twenty-one years that have since elapsed, the author has been largely instrumental in influencing his own company, their competitors, their customers, and the engineering public in general, to recognise the limitations of manganese steel with regard to the kinds of service to which it is suited, and not to attempt its use where it does not give a good account of itself. In conducting this campaign of education, the Taylor-Wharton Company long ago discarded their former policy of publishing as little information as possible about 12 per cent. manganese steel, especially about its demerits, in favour of a policy of spreading as broadly as possible a knowledge of the properties of the steel, its strong points and its weaknesses. Among the latter, as is now quite generally recognised, are its comparatively poor resistance to pure abrasion without cold working, its flowing and spreading under excessive pounding and pressure, and its tendency to fail readily by fatigue at comparatively low stresses. Some of these facts, though perhaps, as Sir Robert states, "known long ago" in England, have certainly not been "generally recognised" there, and the author endeavoured in his Paper to carry to the "home of the invention of manganese steel" his widely-prosecuted campaign to bring about general recognition of both the merits and the demerits of this interesting material.

The soundness of this policy of publicity instead of secretiveness has been abundantly proved, not only by the enthusiastic reception that it has met from our competitors and our customers alike, but by the increasingly satisfactory volume of business in 12 per cent. manganese steel that we transact each year.

* A Paper presented to the Leicester Conference of the Institute of British Foundrymen.

† L. Guillet, "Etude Industrielle des Alliages Metallique," Paris, 1906.

Bethlehem Steel Corporation.—The Bethlehem Steel Corporation reports for the quarter ended September 30 a net income of $4,272,528, after interest, depreciation, depletion, etc., against $4,529,328 in the preceding quarter. For the nine months ended September 30 the net income was $12,186,574, after deducting the above charges, against $13,454,771 in the first nine months of 1927. Orders on hand on September 30, 1928, amounted to $58,725,602, against $51,761,908 on June 30, 1928. Unfulfilled orders represented a total of 634,000 tons, against 614,000 tons at the end of the third quarter of 1927. A regular quarterly dividend of $1.75 was declared on the preferred shares. The directors took no action in regard to the resumption of dividends on the common shares.

The Wet Process of Vitreous Enamelling.

By W. Marshall.

The art of applying a vitreous material or glaze to a metal is very ancient, particularly in connection with jewellery or relatively small articles. It was noted very early that the hard, glass-like finish thus obtained was very desirable from many practical standpoints, but owing to practical difficulties in manufacture, as well as the important items of cost, the use of enamelled surfaces was confined to small articles of relatively great intrinsic value. The beginning of commercial enamelling, as it is now known, may really be considered to come within the past fifty years, and the widespread application of enamelled surfaces in everyday use is a much more recent development.

To-day, instead of confining the activities of enamelling to jewellery and relatively expensive articles, enamelled surfaces are used widely for such applications as cooking utensils, sanitary ware, signs, table tops, stoves, refrigerators, tile, laboratory equipment, large containers, and furniture.

This discussion is not intended to present new or original data on such an old and well-established industry, but it just a discussion of facts which are sometimes overlooked and the classification of certain requirements which have been found to lead to successful results. While it is intended to confine this discussion to the heat applications involved in enamelling, it is necessary, in order to discuss intelligently this phase of the matter, to consider somewhat briefly the nature of the materials used in enamelling and to consider the actions which usually take place when enamel is heated.

Action of Enamel Under Heat.

Most enamels are heterogeneous mixtures of a number of constituents, each with widely different characteristics. In common, enamels are composed of borosilicates mixed with varying percentages of fluxes and colour-carrying ingredients. The borosilicates, of course, form the body of the enamel, while the colour-carrying ingredients give it the desired appearance or its required amount of opacity. In some cases, a single material may serve in several capacities, as in the case of cobalt oxide, which, of course, serves both as a flux and to give a strong blue colour to the enamel.

It is not proposed, in this discussion, to go into details of enamel compositions, but it is of interest to note that in the manufacture of the enamel various materials are usually mixed, some fritted and some unfritted, some thoroughly fused and some unfused, some ingredients substantially in solution in the fused materials and some ingredients entirely undissolved. The important factors to consider in this connection are the effects of temperature, time, and mixture on a heterogeneous combination of this nature. It is evident that continued heating will cause radical changes in the compositions of nearly all enamels. In the same way heating to too high a temperature and such factors as the thoroughness of mixture and the fineness of subdivision of the individual particles will markedly affect ultimate results.

Many of the conditions which are frequently described as erratic can be thoroughly understood when the nature of enamel is kept in mind. Obviously, substances which are present partly in solution will tend to dissolve more thoroughly by continued heating or by heating at higher than normal temperatures. In the same way chemical reactions which may have been partially started in the initial fritting of the enamel have a tendency to progress further on a continued heating.

Incidentally, such conditions explain, in a manner, why certain enamels will radically change their appearance when overfired. Materials used to produce opaqueness such as tin oxide, zirconium oxide, zinc oxide, etc., are somewhat dissolved on continuously being heated, and when dissolved lose a portion of their opaqueness.

Without going extensively into the subject of overfiring and the related conditions at this time, we are dealing with relatively sensitive mixtures of a considerable number of materials having widely different characteristics and subject to different actions on heating.

In addition, of course, the fact that enamels usually contain considerable amounts of silicates and oxides which radically change their appearance when heated in the presence of certain gases multiplies the difficulties of enamelling.

In general, it may be stated that the object of heating the enamels when applied to a sheet of steel or cast iron is partially to fuse the fluxing materials to obtain a firm bond with the supporting material. From the enamel standpoint it is highly desirable, in most cases, to cause the heating to take place as rapidly as possible, and for as short a time as possible. In making the above statement the author is considering the fact that the nature of the supporting material, in most cases, plays an important part in regulating the permissible heating period.

Since properly-prepared enamels have already been subjected to the desired chemical reactions such as fluxing, formation of solution, and admixture of colouring or other ingredients, in most cases the heating operation in the enamelling furnace is designed only to unite the individual particles into a single vitreous surface strongly adhering to the supporting material.

Objectives in Commercial Enamelling.

It is probably unnecessary to state that the two prime objectives in commercial enamelling are (1) high quality, and (2) economy (low cost). In most commercial plants the factor of large production is considered equally with high quality and economy, but since with the proper plant design production depends mainly on size and amount of equipment, this factor will not be considered at length at this time.

General Requirements for Successful Enamelling.

In order to produce a high quality of enamelled product, it is, of course, essential properly to control conditions surrounding the handling and treatment of the material long before it is placed in the enamelling furnace. While the heat conditions in the enamelling furnace are of utmost importance, it is practically impossible to produce high-quality work with small losses if the base material is not properly cleaned and prepared or if the enamel is not properly prepared and applied. As in many other industrial operations, cleanliness is of utmost importance since very small traces of undesirable materials will cause a large amount of difficulty when the enamelware reaches the furnace.

Having properly prepared the enamelled material, its treatment in the furnace may easily determine whether the product is to be high in quality or the reverse, but no amount of care in the firing operation can compensate for improperly pickled or sandblasted materials, a poor enamel mixture or poor spraying or dipping. Incidentally, it is well known that the thinner the coat of finished enamel the higher the quality of the product.

Economy (the second objective) in most commercial enamelling plants depends fundamentally on operating costs which are usually based on the following items:—(1) Amount of labour; (2) losses; (3) material costs; (4) fuel costs; and (5) quantity of production.

An interesting corollary from the above is that fuel costs are in most plants of secondary consideration, and usually represent a relatively small percentage of the total operating costs.

It is of utmost importance to keep the percentage of loss low, and it is easily possible to have a degree of loss which will considerably exceed the total cost of fuel used in enamelling. It is for these reasons that the method of applying the heat, that is to say, the type of furnace used in enamelling is of the utmost importance, and while a high economy of fuel consumption is possible, and should be obtained, the characteristics of a fuel are usually much more important in enamelling than the cost of the fuel.

Assuming that the enamel has been properly prepared and placed on a clean base and thoroughly dried, the characteristics of the furnace become the determining factor in controlling the quality and the economy of the manufacturing operation. This assumes properly trained operators, equipped with the necessary mechanical aids.

Heat Requirements for Successful Enamelling.

While the application of heat to enamelling is a relatively simple operation when understood, much mystery has attached to various phases of this operation. In discussing the subject of heat application, it is pertinent to point out that heat is a form of energy, and like all other forms of energy with which we are acquainted consists of two factors, one of which represents quantity and is called "entropy," while the other factor represents what might be called a measure of activity, and is known as "temperature." The product of temperature and quantity of heat gives the amount of heat energy. It is obviously possible to have a high temperature and yet a relatively small amount of heat, as in the case of an acetylene torch, while, on the other hand, it is possible to have a large amount of heat at a relatively low temperature, as illustrated in the case of a steam boiler. One of the essential problems in enamelling is to transfer the required amount of heat to the article being enamelled quickly, and without departing from the required temperature limits.

It is a well-known fact that heat is transferred by radiation at a rate which varies approximately as the cube of the temperature difference between the hot body and the cold body. The amount of heat transferred in the given time also varies directly with the area of the hot surface and the cold surface; in other words, if one square foot of hot surface will radiate 1,000 B.T.U.'s per hr., two square feet, under similar conditions, would radiate 2,000 B.T.U.'s per hr. Therefore, it will be apparent that we have available a means for increasing the rate of heat transfer without increasing the temperature difference.

Since in the earlier discussion it has been pointed out that time is an essential element in the application of heat in enamelling it will be apparent that by controlling the amount of radiating surface we have another factor which is sometimes neglected in designing enamelling furnaces.

While the materials which are usually enamelled have a relatively thin surface coating there is an appreciable time lag between the instant the article is placed in the furnace and the time that it reaches the desired temperature. All materials expand on heating, and the raw enamel coat previous to firing expands at a different rate from the metal which carries it. For these and other reasons, it is theoreticaly desirable, if practicable, to submit articles to be enamelled to a rising temperature. The theoretical objective would be to place the article to be enameled in a relatively cool place, and raise the temperature of the furnace as the enamelling progresses.

In many cases this is not practical, but, on the other hand, in dealing with heavy articles or complicated shapes, such a treatment is highly desirable, or else as an alternative the temperature of the enamelling furnace must be lowered with a corresponding increase in the enamelling time. Obviously a heating cycle which submits the articles to be enamelled to a falling temperature instead of a rising temperature, is the reverse of desirable, in most cases.

Probably the foremost requirement of an enamelling furnace is controllability of temperature. It is true that many enamelling plants which depend upon the skill of the operators are producing highly satisfactory work in furnaces not capable of accurate control, but it would seem that this practice is reverting from a manufacturing process to an art in which in place of mechanically-fixed conditions, human judgment is being depended upon. This does not seem to be good practice in many cases, although there are undoubtedly conditions which make exceptions to this rule desirable.

In addition to maintaining a controlled temperature it follows that the temperature should be known or proper indicating or better recording instrument should be used.

Because of the presence of silicates, oxides, and other compounds which are readily affected by reducing gases, oxides of sulphur, and some products of combustion, it is essential that the source of heat must be clean. This may be obtained by completely muffling the products of combustion or by selection of the fuel and means of handling it. This subject will be discussed at greater length in considering some factors of furnace design.

In addition to maintaining a controlled temperature in the furnace the amount of heat must be sufficient satisfactorily to carry on the enamelling operation. It is not sufficient to have a furnace which is at the required temperature, but which shows a rapid fall in temperature when the door is opened or when the work is placed in the furnace. As previously pointed out, the quantity of heat represents a different factor from the temperature of the furnace. As will be shown later in consideration of furnace designs, the quantity of heat depends upon such factors as type and design of muffle, area of radiating surface, and other constants.

It is hardly necessary to state that in addition to having sufficient heat and a controllable temperature, the temperature must remain constant at the desired value. It is desirable in order to secure the most uniform manufacturing conditions, to provide equipment for automatically holding the temperature constant. This condition can, of course, be approached by manual operation, and there are a number of plants in which the personnel operating the furnaces are sufficiently trained to enable them to produce a high quality of work with small loss, when depending on their own judgment of temperatures. It is the writer's feeling, however, that such a condition is not as desirable as one in which conditions are automatically maintained constant.

It is essential for economical production with small loss to maintain a uniform distribution of heat. In other words, in order to operate an enamelling furnace at maximum capacity and efficiently, all portions of the furnace should be at substantially the same temperature. This refers not only to all portions of the hearth, but also requires substantially uniform conditions in considering the hearth, the side walls, and the top of the furnace. It is obvious that a furnace, portions of which are below the required temperature, cannot be successfully used for enamelling under ordinary commercial conditions without involving heavy losses. The same is true of a furnace which shows points of too high temperature. The final result of a non-uniform heat distribution is to restrict the workable area of the furnace, which involves an increased investment for a given output.

Perhaps the least important factor in connection with furnace heating is the subject of cost of fuel. It is obviously desirable to maintain a low fuel operating cost, and to secure as low as possible a first cost for the equipment used. In general both of these factors are not so important as the ability to produce large quantities of high-grade ware with small losses. An analysis of the division of operating costs in the average enamel plant will usually demonstrate this condition very conclusively.

Types of Enamelling Furnaces.

There are many types of enamelling furnaces in use both in the United States and in Europe, but in general these may be classified as the intermittently fired furnace, and the continuously fired furnace. The intermittently fired furnaces represent a type in which no heat is applied while the ware is in the furnace, all heating being done by the direct combustion in the enamelling chamber of the fuel between the intervals of firing.

Such a type of furnace offers the advantage of eliminating the muffle which is commonly used in many of the continuously fired furnaces, but on the other hand usually involves a reduced capacity due to the slower speed of operation. The intermittently fired furnace also inevitably involves the characteristic of firing the ware in a falling temperature, and further necessitates operating over a rather wide range of temperature instead of at a single fixed temperature as in the case of most continuously fired furnaces. It seems evident that a furnace of this type requires considerably greater skill for satisfactory operation and is likely to involve greater losses than the continuously fired type of furnace. The fuel economy of the intermittently fired furnace is fundamentally no higher than a properly designed continuously fired furnace, and in many cases the fuel requirements are higher for the intermittently fired furnace.

The continuously fired furnace may be divided into the three general classes:—(1), Unmuffled; (2), semi-muffled; (3), fully-muffled type. The unmuffled type of furnace is used relatively infrequently as it requires a specially compounded enamel not affected by furnace gases and usually involves considerable judgment and control on the part of the operator.

The semi-muffled furnace has been used in several instances, and offers the advantage of slightly reduced first cost as compared with a fully-muffled furnace. On the other hand, the semi-muffled furnace cannot be forced, and requires a considerable amount of care in operation to avoid serious losses due to the action of furnace gas on the enamel, and also due to non-uniform heat distribution. In general, it would appear that the semi-muffled furnace required greater skill on the part of the operator, and therefore is not quite so nearly fool-proof as the fully-muffled type.

When properly designed and constructed, the fully-muffled type of furnace would appear to offer the following advantages in the average manufacturing plant:—(1), Large capacity; (2), quick enamelling; (3), absolute cleanliness of heat; (4), uniform heat distribution; (5), high heat capacity; (6), long life; (7), high fuel economy; and (8), small losses.

Enamelling furnaces may be classified as regenerative and unregenerative, depending upon whether or not the equipment is provided to recover a portion of heat in the stack gases. In nearly all commercial plants the additional investment to recover the portion of heat in the stack gases is well justified. Such an arrangement also serves, in addition, to increase the efficiency of the furnace by maintaining a cleaner, more satisfactory combustion, and more uniform temperature conditions within the furnace.

Many attempts have been made to produce enamelling furnaces in which material travels through the furnace continuously instead of being placed in the furnace and then removed. There are some theoretical advantages to a construction of this type in handling a production of large quantities of similar articles. In many enamelling plants, however, the advantages of a continuously operated furnace are more apparent than real, due to the wide variation in the character of the material to be enamelled. There does not seem to be unsurmountable mechanical difficulties in constructing a continuously charged enamelling furnace where plant conditions make it desirable.

Some Desirable Furnace Characteristics.

The design of a furnace to secure the best all-round practical results involves a consideration of many varying factors, most of which are recognised, but some of which are frequently neglected. It is essential that the furnaces be of ample size for handling the amount of work required, and, in general, where the production requirements permit, a few large furnaces are more desirable than many small furnaces. On the other hand, since increased size means increased first cost and increased radiation losses, it is desirable to keep the furnaces as small as possible and yet turn out the required production.

It is always desirable to insulate a furnace thoroughly, not only from the standpoint of fuel economy, but also to maintain more comfortable working conditions in the plant and to make it possible to maintain constant temperature conditions.

The door of the enamelling furnace is one of the important sources of heat losses particularly during the time that it is opened. It is, therefore, important to secure quick operation of the door, quick loading and unloading of the furnace. The door should be thoroughly insulated, and make a tight seal with the sill and jambs to prevent heat losses.

The fuel should be burned in a reliably controlled manner, and the products of combustion which carry the heat should be distributed throughout the furnace flues in such a way as to give controllable, but uniform heat distribution.

The muffled type of furnace is desirable in most cases, and where the muffle is used it should be made of permanent durable material having a high heat conductivity (such as carborundum).

Where the heat conductivity is sufficiently high to permit it, it is desirable to use a relatively thick-walled heavy muffle. A construction of this kind serves to store heat so that enamelling may be carried on with a substantially uniform or rising temperature gradient rather than with the falling temperature.

It is desirable to supply as large a heat radiating surface as possible in the muffle walls. A recuperator is desirable both from the standpoint of economy of operation, uniformity of operation, and control of furnace conditions. A furnace should be constructed in such a way that it will be relatively quick in reaching the operating temperature, and yet will hold its temperature for considerable periods when not in use.

Desirable Fuel Requirements.

There are many considerations which influence the choice of a fuel for an enamelling furnace installation. In the order of their relative importance, these may be listed approximately as follows:—(1) Controllability; (2), cleanliness; (3), reliability; (4), uniformity; (5), economy of operation; and (6), economy of first cost.

The usual fuels employed in enamelling may be enumerated as follows:—(1) Towns' gas; (2), oil; (3), producer gas; (4), electricity; (5), coke; and (6), coal.

Much may be said as to the relative advantages of each of these fuels. Towns' gas appears to be unquestionably excellent in meeting all of the requirements stated above, although it is not the cheapest fuel from the standpoint of operating cost. Towns' gas is clean, controllable, reliable and uniform.

Fuel oil is a commonly used source of heat, and when properly employed will give excellent results. It has the advantage of being lower in first cost than towns' gas under some conditions, but it is not quite so controllable, clean, or reliable as city gas.

Producer gas under most conditions is not quite as desirable a fuel as city gas or oil. The cost of producer gas is frequently under-estimated, and where proper allowance for overhead is made, producer gas will frequently show a higher operating cost than either oil or towns' gas. Producer gas is usually subject to considerable variation in quality and cleanliness. For these reasons it is not as easily controlled as towns' gas or oil, and from the standpoint of uniformity and reliability, it is sometimes subject to question.

Electricity is a highly desirable source of heat from practically every standpoint except that of economy and flexibility. In most cases, the operating cost of electrically-heated equipment is higher than in the case of fuel-heated furnaces. Another difficulty inherent in electrically-heated enamelling furnaces is the relatively small production obtainable with a given investment. This can be illustrated by pointing out that a furnace which will produce 1,000 sq. ft. of enamelled material per hour when heated by towns' gas would, if heated by electricity, produce less than half the output. For this reason the first cost of the installation of an electrically-heated enamel plant is likely to be much greater than a fuel-heated plant.

Coke and coal are solid fuels which apparently are being rapidly displaced in the enamelling fields. Aside from the low first cost of the fuel itself, there is little to recommend them. Usually the low first cost of the fuel is more than counterbalanced by the additional labour and attention, the increased skill required on the part of the operators, and the tendency to involve relatively large losses in the form of defective ware.

Mr. Henderson Addresses Burnley Technologists.

Under the auspices of the Burnley Section of the Lancashire Branch of the I.B.F., an open meeting, to which members of the motor, engineering and foundry trades were invited, was held at the Burnley Technical College on Saturday, October 13. It was presided over by the Right Hon. Arthur Henderson, M.P., who was introduced to the meeting by Mr. T. Greenwood, the President of the Section. Mr. W. West, of Leyland, gave a lecture on "Oil Sand Cores," a summary of which has already been printed in these columns. This was followed by a film illustrating the making of motor cylinder castings at the works of Leyland Motors, Limited.

The Chairman said he was delighted to have the opportunity of presiding over this lecture. It was not the first occasion that he had been brought into touch with the Institute; just over two years ago he had the privilege of opening on their behalf a very interesting exhibition in London, and a few months ago he spent an evening with the London branch of the Institute. He had been a little puzzled as to why he received so much attention from the Institute. Looking through the Book of Rules he found that in the conditions of membership certain qualifications were prescribed for honorary members; they were to be persons distinguished in science, literature, art, or manufacture. He could find nothing which would entitle a poor politician to be eligible for ordinary membership, and he could not profess to be qualified under any of the four heads that he had named. So he was driven to the conclusion that when he was invited and became privileged to take part in the Institute the rule as to qualification must have been stretched, for the reason that in the old days before he was called upon to mould public opinion he was responsible for moulding castings.

What he had read about the work of the Institute, which he very decidedly commended, brought back to his mind the old days. For some 16 or 18 years, between the hours of six in the morning and five at night, he was doing what some people would term, trying to spoil sand by making castings. These reminiscences were, to himself, at any rate, most interesting.

Insufficient Recognition.

The foundry industry, he believed, was far more important than the general public realised. He did not know why it was, but a number of people who were interested in engineering had a poor appreciation of the work that was done in the foundry. That had impressed him very much during the whole of his working life. When he was brought into contact with the Institute and with the other very valuable educational institutions which now existed, he recognised what a powerful factor they could be in helping industry. When he served his apprenticeship none of the towns that he lived in was able to offer to an apprentice in the foundry trade anything like the course of instruction which was now available in Burnley. He believed the reason was that in those days the work done in the foundry was little appreciated, and he thought foundrymen themselves were very largely responsible for that deplorable condition of affairs. Just before the meeting began he was talking with a few others in an adjoining room, and he remarked on the revolution in habits that had taken place. More than 45 years ago he began to attend the meetings of his union in connection with the foundry industry, and he remembered how indifferent the men were, how difficult it was to induce them to attend. A remarkable change had taken place; the transformation was so complete that in subsequent years they had a branch where every officer was a credit as a citizen.

The point he wanted to bring out was that such Institutions as the I.B.F. raised the standard in an industry. One of its objects was to work in connection with other educational institutions, and an example of that co-operation was seen in Burnley. When the tone of the industry was elevated and men began to have a proper pride in themselves and in their craft, other people took notice of them. If men dragged down their craft people spoke lightly of them, and presently began to despise them. So when these opportunities for improvement came along he was delighted to use all the moral influence he could to assist and encourage all those who were endeavouring to profit by them.

Some three or four years ago he visited the United States of America, and came into contact with some of the great industrialists there. He spent a very interesting morning at Detroit in the works of the great motor firm which had given a lead to the whole world. The head of the firm was prepared to show him everything that he desired to see in connection with those great works. Now he wanted to say this, that throughout the very serious depression in trade which had been experienced during the last seven or eight years he had never allowed himself to entertain the thought that from an industrial standpoint this country was deteriorating. He had realised, as every man must realise who travelled, that never again could they expect to have the elbow room which they formerly had when the British people were pretty well the masters of the economic situation of the world, when people outside looked to them to supply industrial needs. There again a tremendous change had taken place. Other nations were more industrialised to-day than they had ever been before, and this country had first-class competitors. It was of the highest importance to realise there were such competitors, and that they must find out the most effective way of holding their own.

Practice and Theory.

Two extremes must be avoided. One extreme was to know the practical without the theoretical, the intellectual, the scientific. The other extreme was to know nothing about theory, but to have full regard for the importance and essentialities of practice. In his judgment to enable this country to compete more successfully against other industrial nations, all those engaged in an industry, both on the practical side and on the directive side, should have the highest possible standard of intelligence and education with which to combine their practical knowledge.

He hoped the lecture they were about to hear, and the pictures they were going to see upon the screen, would contribute to progress in the direction he had indicated, and that all present would be so benefited that they would be better fitted to discharge their responsible duties. It was essential that all who participated in management as well as in the productive work should be equipped to the highest possible standard.

He hoped the Burnley Education Authorities would continue to provide the classes with every facility, in order that educational work in foundry subjects might be effectively carried through and that the students might go further than the theoretical side and get down to actual moulding.

Mr. West gave his lecture, during and after which questions were put to the lecturer, and the following replies were given:—

The question was asked—Was any special method adopted of control to maintain the consistent regularity of metal coming from the cupola?

Mr. West replied that no special method was in practice, except that a practically-minded chemist was on the cupola stage and indicated what was required in the way of selecting the scrap and generally co-operating with the foundry staff. Samples of iron were taken at intervals—the analyses of which gave indication of the working.

It was further asked—To what extent was steel mixed in the furnace charges?

In reply, it was stated that approximately 20 per cent. steel was used, but this was not added as a direct addition to the furnace charge, but in the first instance was melted in the electric furnace to give an iron containing 2.0 per cent. total carbon and 2.0 per cent. silicon.

With regard to the method of making castings in multiple moulds, an inquiry was made whether there was not a great risk of damage occurring when the metal was dropped from a height, considering, if it were so, that the moulds were made in green sand.

Mr. West replied that the moulds were entirely dried, consequently there was no risk attendant to the casting from an increased height—the only danger being that a burst might occur if insufficiently weighted down.

Mr. Hogg stated that some people, particularly in America, attached more importance to control of the silicon than to control of the total carbon. Which did Mr. West consider was the more important? Judging by the figures shown on the screen, the total carbon was never more than 3.3 per cent., and it had been as low as 3.1 per cent.

Mr. West replied that they did not attach greater importance to the silicon control than the total carbon. The total carbon was difficult to control, but by making a steel and iron mixture they were able to get the percentage down to 3.1 per cent., which enabled a little higher percentage silicon to be used.

Vote of Thanks.

Mr. Makemson said he had to discharge the very pleasant duty of expressing the thoughts of the audience, as well as his own, by saying how grateful they were to Mr. West for having given them this lecture and to Mr. Henderson for presiding. Mr. Henderson had rather suggested they must have stretched a point in electing him to be an honorary member of the Institute. He did not know that that was so. Mr. Henderson was a foundryman and a very distinguished man. He had achieved very considerable distinction, not in managing foundries but in another walk of life, and in making him a member of the Institute they felt they were honouring themselves as well as Mr. Henderson. They were very proud of him as a member, and very much obliged to him for the interest he took in the work of the Institute.

The Institute also owed a great deal to Mr. West, and to the firm with which he was connected, Leyland Motors. They had one of the most up-to-date foundries in this country, they had experimented in many directions, they were far ahead of many rivals, and the results of all this work had been put quite freely before the foundry trade without any reservation or holding back. They had done an enormous amount of investigational, experimental and research work, and they had placed the results of it quite freely at the disposal of the whole of the foundry industry. Mr. West had repeatedly lectured—he thought to almost every branch of the Institute—giving the latest information concerning the work which he had done at Leyland.

That spirit was what the Institute of British Foundrymen stood for—the spirit of co-operation in industry, of pooling information. The day when every foundry worked on its own, guarded its recipes and processes and refused to disclose them to anybody else had happily passed. The man who would not state what he did in his foundry usually had little to tell. The people who were accomplishing things were generally quite willing to tell somebody else about them. By getting together, by exchanging information, progress was made possible, and the progress which had taken place in the foundry trade coincided with the growing tendency to pool information and to co-operate.

He wanted to explain a few things about the Institute. It was disinterested in questions between employers and workmen. Such matters were dealt with effectively by employers' associations and trade unions. But the work of the Institute was to discuss how a casting was going to be made and how it could be improved. Its attention was devoted to the improvement of technique, the improvement of the methods of making castings, the improvement of materials, the scientific standardisation of methods and materials. During the 24 years that it had existed enormous advance had been made in the technique of foundry work, and he claimed that it was due largely, if not almost entirely, to the Institute as a whole and to the individual members who unselfishly pooled their information and co-operated together. Mr. West had been telling them about oil sand. Most of those present could remember when oil sand was something of a curiosity. The rapid strides which had been made by the use of oil-sand cores had been made possible through the work of the Institute, and all individual members like Mr.

West. The standardisation of cupola practice, the scientific and systematic control of cupola practice which had been made possible in recent years was almost entirely due to the Institute.

He appealed to those who were not members of the Institute to consider seriously the advisability of joining it. Meetings were held regularly in Burnley; the Burnley Section included some of the most enthusiastic foundrymen he had ever met, and they deserved to be backed up by local foundrymen. The foundry trade was changing rapidly, new methods and new processes were introduced, and in order to keep abreast with the times it was necessary to be in touch with what others were doing. The Institute was the medium by which that could be done.

In seconding the vote of thanks, Mr. Hogg said Mr. Henderson had spoken to them that evening in an optimistic strain, and when they took into consideration that he had travelled on the Continent and in the United States they must give credit to his words as being a very valuable indicator of the trend of events. He told them that in spite of the depressed state of trade during the past few years the British workman could hold his own if he would try to keep up to the modern standard. That was so in the foundry industry. Foundrymen must rise to the standard of intelligence and education which was needed in these days. It was a higher standard than was required twenty years ago. In those days anyone who had to deal with metal judged it by fracture, now it was necessary to know about the phosphide eutectic, carbides and so forth. It was impossible for the ordinary workman to learn much about those things in the foundry itself, but the means for acquiring knowledge were provided by the Institute. The man who wanted to learn could attend the meetings held in connection with the Institute, or, if he could spare the time, the foundry classes provided by the education authorities.

He wanted to express his personal thanks to Mr. West for his readiness to come forward and prepare this lecture for their benefit. He always responded to their appeals: they had never yet had a refusal from him. Meetings of this kind, which did so much to benefit the industry, were made possible by the work of the Institute of British Foundrymen.

Plastic Contour.

The London Local Section of the Institute of Metals held its monthly meeting at the Royal School of Mines, South Kensington, S.W.1, on Thursday, November 8, when Professor W. E. Dalby, F.R.S., gave a lecture entitled, "The Plastic Contour."

Professor Dalby, in his address, dealt with the development of the instruments which he had defined for the examination of the mechanical properties of materials. He showed many interesting lantern slides to illustrate the different stages of the development of his machines, afterwards describing the results of his tests, and discussing some of the problems which arose when a metal expanded or contracted under stress. The lecture aroused an interesting discussion.

Braintree Claims New Record.

Messrs. Lake & Elliott, Limited, of Braintree, have recently placed into commission an Ajax Northrup high-frequency furnace for the manufacture of steel castings. They claim that this is the first installation in the country to be engaged upon this particular duty, although a similar type of plant has been installed in a large foundry in Sheffield, it is not used for making castings.

A Remarkable Escape.—A cupola charger at the Cyclops Foundry, Glasgow, had an alarming experience last week. A large piece of scrap which he was putting through the charging door became entangled in his apron and pulled him head first into the furnace. He was promptly rescued by his mates and found to be suffering from a cut on the head. After having the wound dressed he returned and worked out the shift.

Abrasive Papers.

By Fred. Grove-Palmer, A.I.C.

Very large quantities of abrasive papers are used by patternmakers, car-body builders and re-painters in the course of their work, and practically every user in this country has his preference for one brand over another without being able to state exactly what that preference is founded on. One will say, quite definitely, that X is better than Y, because it lasts longer or cuts better, which would be good enough if the next user did not give an opinion that is exactly the reverse. In view of these conflicting ideas, it is very difficult to assess the values of the rival makes of "grits."

There can be little doubt that the larger part of the abrasive papers used in this country are of American origin, although there are no difficulties in the way of obtaining papers of domestic manufacture; whether the motor industry prefers the foreign papers because they are better, or for some other reason, it is not easy to understand. It is probable that the reason is a purely natural one, namely, the materials are more readily obtained abroad, and consequently the work done in the way of research towards the improvement of the prominent characteristics of the paper, cutting and endurance, has possibly been greater than has been considered necessary at home.

Abrasives may be divided into two classes—natural and artificial. The natural class includes emery, corundum, garnet, quartz, and some others which do not concern the present inquiry.

Corundum is an oxide of aluminium which in some conditions appear in nature as gems, such as ruby, emerald, sapphire, and some of the less valuable jewels. It also occurs in masses, in which form it is valuable for abrasive purposes, and is mined in various parts of India, at Palmer Rapids in Ontario, at Leysdorp in the Transvaal, and in North Carolina. Emery is a variety of corundum with which is usually found, in natural admixture, magnetic oxide of iron, hematite, and sometimes spinel, a hard mineral containing iron, aluminium, magnesium and other metals in various combinations.

Garnet is a silicate of iron, aluminium and other metals; when found in large pieces of good colour it is of value as a jewel, but vast quantities of garnet powder are used for abrasive purposes, although the general concensus of opinion appears to be that it is inferior in hardness and cutting quality to the artificial materials to be described later.

The use of natural abrasives has been very greatly reduced by the introduction of artificial materials of exceeding hardness, one of them largely employed for this purpose being "Carborundum," a name made up of "carbon" and "corundum." This was first made by Acheson, the great American authority on graphite, who formed it accidentally in his researches in the direction of manufacturing artificial diamonds. He noted that its hardness was inferior only to that of the diamond itself, and decided that as it was of no use as a jewel it might be valuable as an abrasive, which proved to be correct. It is made in large quantities on the American side of Niagara Falls, and also to some extent on the Canadian side. A batch consisting of 30,000 lbs. of a mixture of sand, coke, sawdust and common salt is charged into an electric furnace, for which the Falls supply the power, and cooked for 36 hours. It is then dug out, pounded in mills, digested with warm sulphuric acid to remove the impurities, washed with water, graded, and dried in kilns. The yield is about 6,700 lbs. of useful carborundum and about 5,000 lbs. of matter that is similar in composition but is not crystalline in structure. This is used for firebricks and kiln-linings. The chemical composition is C Si—carbon silicide or silicon carbide. It is entirely infusible below 2,220 deg. C. (4,028 deg. F.), and is unaffected by acids or atmosphere.

A very large quantity of the high-grade waterproof abrasing papers made in England and America employ carborundum of varying degrees of fineness as the cutting agent, and for many years it was considered to be without an equal, but of recent years there has been a tendency on the part of some users to prefer an artificial corundum or oxide of aluminium which appears on the market under various trade names, such as, "Aloxite," "Alundum," "Exolon," etc. This material is not perhaps so sharp as the caborundum, but on waterproof papers it is found to be tougher and not quite so brittle.

The effects of this difference to the user are very marked. In the first place, the toughness causes the papers to last longer, and therefore do more work, and it should be that much cheaper; but, more important still, because it is not so sharp as the carborundum, the artificial corundum does not possess the same liability to cause scratches on the surface of the enamel. Thus a fine finish is more certain, and this in itself is a very valuable property.

The grades of paper most generally used are 180, 220, 320, and occasionally 400, when an exceptionally good finish is needed. The corresponding grades of garnet paper are No. 5/0 (180); No. 6/0 (220); No. 9/0 (320). There is no garnet paper of a grade equal to 400.

In America the re-paint shops use large quantities of garnet papers, while the big production firms use either carborundum or aloxite. This is probably largely a matter of price, as the small man would naturally prefer the article that looks cheapest irrespective of its quality.

This is certainly a question that every user of "emery" paper should go into very thoroughly in order to discover for himself which brand does actually give him the best results. A trial with half a sheet will not give a reliable verdict; it should be done systematically and a number of times with different workers in order to get a fair average of results to assist in forming a judgment. Then the question of costs should be gone into. In this way the relative virtues of the home and foreign brands may be ascertained, and if the home production is found to be wanting in any direction, it will give the manufacturers an opportunity of setting their houses in order.

Volume Changes in Cast Iron.

In connection with Dr. Donaldson's Paper on "Volume Changes in Cast Iron," presented on behalf of the Institute of British Foundrymen to the Association Technique, Mr. Renaud writes as follows:—

The important work of Dr. Donaldson, which has been conducted in such a systematic manner that it can hardly lend itself to criticism, is specially destined to verify the numerous results which have been communicated during the past twenty years on the subject by Charpy, Grenet, Campion, Hurst, *et aliter*.

The author leaves aside all these acquired results and studies the influence of carbon, manganese, phosphorus, and silicon, and gives definite information on the influence of these elements which in the future will be useful to many foundrymen.

However, in his conclusions, the author says that he has not considered it necessary to carry tests on a series of cast irons with variable sulphur contents, basing his reasoning on the fact that Stead and Levy have shown that "when sulphur exists in the form of MnS it is practically without influence on the structure and on the properties of the cast-iron." From this the author takes for granted, practically *a priori*, that a variation of sulphur between 0.05 and 0.15 has very little influence on the stability of cast-irons during the heat treatment that he envisages in his Paper. It seems to the writer that Dr. Donaldson should have pursued his research by studying the influence of sulphur.

All the more so because (1) Mr. Schwartz proves that sulphur has an influence on the stability of cast-iron when hot, as he includes this element in those that retard graphitisation; (2) all foundrymen, and particularly those who manufacture rolls or chilled castings, will agree that sulphur maintains the carbon in the combined state and increases the depth of the chill. The author himself says that the initial quantity of graphite often has great importance on the resistance to heat of cast-iron.

These two points tend to show that Dr. Donaldson might give us for sulphur the same facts that he has given us for the other elements.

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Trade Talk.

Two of the Summerlee Iron Company's blast furnaces, which have been out of blast for some months, have been relit.

The Great Western Railway Company have placed with Messrs. Vickers-Armstrongs, Limited, an order for a pair of steel lock gates for Penarth Dock.

It is understood that Messrs. Alfred Hickman (branch of Stewarts & Lloyds, Limited), are about to build a new Siemens steel furnace at their Bilston works.

An order for a cargo vessel of 2,000 tons for American owners has been booked by Messrs. Palmers Shipbuilding & Iron Company, Limited, Jarrow-on-Tyne.

The Shotts Iron Company are at present reorganising their foundry department. It is proposed to re-equip the foundry with machines and other plant of a modern character.

Messrs. D. & L. Tullis, engineers and makers of laundry machinery, Clydebank, are extending their foundry; a new melting unit, with Poumay cupola, is in course of erection.

Messrs. William Gray & Company, Limited, shipbuilders and engineers, of West Hartlepool, have work in hand sufficient to last them until next July, and intend re-opening their Wear shipyard.

The Klöckner Works, A.G., one of Germany's leading iron and mining concerns, proposes for the business year ended June 30 a dividend of 6 per cent., as against 7 per cent. in the previous year.

The Duffield Iron Corporation, Limited, have acquired Park Farm, Adderbury, Oxfordshire, for the purpose of erecting works to demonstrate the new Duffield process. The site comprises five acres.

Additions are being made to the Hawarden Bridge Ironworks at Shotton, owned by Messrs. John Summers & Sons, Limited, to provide departments for the manufacture of sheeting for motor-car bodies.

Messrs. Alfred Herbert, Limited, of Coventry, announce that their American licensees, the Riley Stoker Corporation, have recently secured seven new orders for Atritors from five firms in the United States.

J. & J. Dyson, having completed the erection of a new suite of offices at their Stannington Works, they are now proceeding with the rebuilding of a portion of their works at Chesterfield for the manufacture of foundry blackings, coal dust and other foundry supplies.

A new company, under the style of Compagnie Francaise Buell Combustion, with 12 million fcs. capital, has been registered in Paris. The promoters include the Etablissements Loy et Aube, and the Buell Combustion (Foreign), Limited, of Aldwych House, London, and the first board includes the chairman of the Penhoet shipbuilding yards.

Following the successful working of Worthington two-cycle double-acting marine Diesel engines in U.S. Shipping Board vessels, the Société d'Electricité et de Mecanique, Procédés Thomson-Houston et Carels, of Belgium, have made arrangements with the Worthington Pump and Machinery Corporation of the United States for the manufacture of this type of engine at the Carels works at Ghent.

The Central Electricity Board have placed contracts, amounting in all to more than £600,000, for the supply and erection of the 132,000-volt outdoor switchgear included in the South-East England electricity scheme, as follows:—For Part I, covering the northern portion, with Messrs. A. Reyrolle & Company, Limited; for Part II, covering the southern portion, with the English Electric Company, Limited.

Messrs. Cox & Danks, Limited, who successfully raised the cruiser "Molkte" last year, have now succeeded in floating the ex-German battle cruiser "Seydlitz." The "Seydlitz" was originally lying on her side quite close to the "Hindenburg," and was considered the most difficult proposition in Scapa Flow. It is the intention of Messrs. Cox & Danks, Limited, to sell the vessel to another firm of shipbreakers, and she will no doubt be ultimately towed to Rosyth Dockyard for breaking-up purposes.

Sir Brodie Henderson, in his presidential address to the Institution of Civil Engineers, advocated the adoption of steel sleepers by the railway companies in Great Britain, and added that the money spent on foreign timber for sleepers would thus be diverted to the steel manufacturers. Permanent way was being gradually improved in all countries, and the heavy rail was being widely adopted. The present trend was towards more powerful locomotives, which were particularly suitable for countries where oil fuel was used. Special steels were being increasingly used, and more efficient valve-gears were being tested.

Messrs. Stewarts & Lloyds, Limited, some time ago interested themselves in the Coley process for the manufacture of zinc, and became substantial shareholders in the N.C. Metal Company, Limited. The latter, formed to develop the process, has been working in England on a full-scale plant for some months, with results stated to be entirely satisfactory. It has now been decided to increase the capital of the N.C. Metal Company by at least £250,000, with a view to the full development and working of the process throughout the world. The N.C. Metal Company have the complete rights and have already issued licences in respect of England, France, Spain and Portugal. In England the manufacturing company which has taken the licence, the N.C. Zinc Oxide Company, is putting down a number of plants to ensure a substantial output of zinc. Messrs. Stewarts & Lloyds, Limited, are erecting a plant of their own.

The Coventry Malleable and Aluminium, Limited, Lincoln Street, Coventry, is increasing the scope of its business by including the manufacture of aluminium castings in addition to malleable iron castings, in which it has long specialised. It has taken over from the Rover Company, Limited, as a going concern, their aluminium foundry at 42, Spon Street, Coventry, together with outstanding orders, equipment, staff and workpeople, and will continue to maintain the quality for which the Rover Company has been so well known. Mr. F. H. Hurren, who for the past 24 years has been chief chemist and foundry manager at the Rover works, has been appointed joint managing director, and will be responsible for the manufacturing side of the business. The firm has just completed an extension to its malleable foundry, and has laid down a complete new melting plant which is claimed to be one of the most modern equipments in this country.

Verdon Cutts & Company, Limited, of Town Hall Chambers, 87, Fargate, Sheffield, have in hand at the present time the following orders for electric furnaces and industrial electric heating apparatus:—A 120-kw. electric furnace for heat-treating carbon, alloy, and special steels in Dominion railway shops; a 50-kw. brass melting furnace for Dominion railway shops; a 15-kw. Babbitt melting pot for Dominion railway shops; a 24-kw. electric hardening furnace for Sheffield steel works; a 85-kw. brass melting furnace for extrusion metal, for a well-known brass foundry in Doncaster; a 50-kw. electric furnace for forging and heat-treatment of rock drills in Canadian mines; a new type electric assay or cupellation furnace for a Dominion mint; a 120-kw. electric furnace for normalising and hardening drills, tools, and rock drill parts in a South African gold mine; a 35-kw. electric furnace for heat-treating rock drill parts in a Dominion mining area; an electric furnace for case-hardening, carburising, heat-treatment, etc., of rock drill parts on the Rand; a 10-ft. electric furnace for heat-treatment of continuous strips of special alloy steel in a Sheffield steelworks; an electric stereotype melting pot for melting metal for production of a daily newspaper in the North of England; electric furnaces for heating brass billets for hot stamping; a large electric furnace for heat-treatment and annealing of fillets and blanks for a Dominion mint; and two electric furnaces for the heat-treatment of gold and silver coinage blanks for mint purposes.

Obituary.

Mr. D. W. Sillars, of Penarth, who was South Wales representative of Messrs Dorman, Long & Company, Limited, for many years, has died in his 70th year.

The death has occurred in Derby of Mr. T. Hyde, one of the best-known men in the local foundry industry. The deceased, who was 65 years of age, lived at 69, Portland Street, Derby, and for a period of 35 years had been in the employ of Messrs. Leys Malleable Castings Company, Limited, as a chain-tester. There was a large number of mourners at the funeral, and the firm of Messrs. Leys was represented by Mr. Allen and Mr. Evans.

Sir Alexander B. W. Kennedy, whose death occurred recently, was a veteran engineer of remarkably varied experience. Born in 1847, he was educated at the City of London School and the School of Mines, Jermyn Street, and at about the age of 16 became a pupil in marine engineering with a firm at Millwall. He was subsequently with Messrs. Palmers at Jarrow-on-Tyne, and with Messrs. T. M. Tennant & Company, at Leith, and for a few years carried on a consulting practice at Edinburgh and Glasgow. In 1874 he was appointed Professor of Engineering in University College, London, leaving in 1889 to build up an extensive practice as a consulting electrical engineer. He received his knighthood in 1905. He was President of the Engineering Section of the British Association at the Oxford meeting in 1894, of the Institution of Mechanical Engineers in 1894-5, and of the Institution of Civil Engineers in 1906. He was elected a Fellow of the Royal Society in 1887.

Contracts Open.

Barnsley, November 27.—8,200 yds. of cast-iron pipes, etc., for the Town Council. Mr. J. R. Fox, waterworks engineer and manager, Doncaster Road, Barnsley. (Fee £3 3s., returnable.)

Congleton, November 19.—Pipes and specials, for the Corporation. Mr. W. H. Duncan Arthur, Town Hall, Congleton.

Slough, November 19.—1,275 yds. of cast-iron pipe, for the Urban District Council. Mr. A. Bromly, surveyor, William Street, Slough.

Mortlake, Surrey, December 10.—Pumping machinery, etc., for the Richmond Main Sewerage Board. Mr. W. Fairley, Parliament Mansions, Westminster, S.W.1. (Fee £3 3s., returnable.)

Salisbury, Rhodesia, November 29.—Pumping plant, for the Municipal Council. The Department of Overseas Trade. (Reference A.X. 7089.)

New Companies.

Allied Waste Metal Products, Limited, 18, Great Dover Street, London, S.E.—Capital £100. Directors: S. L. Gibbs and M. F. McCoy.

Timmins Bros., Limited, 106, Bagot Street, Birmingham.—Capital £1,000. General casters, etc. Directors: L. F. London and C. E. Cowney.

Robert Keith & Company, Limited, 12, Cherry Street, Birmingham.—Capital £500. Manufacturers of metal ware, etc. Directors: W. E. Dempster and R. Attiwell.

Melingriffith Transport Company, Limited.—Capital £3,000 in £1 shares. Carriers, warehousemen and storers of coal, iron, steel, etc. Directors: H. Spence-Thomas and W. J. Spence-Thomas. Solicitors: Spencers & Evans, 6, Working Street, Cardiff.

Sturtevant Engineering Company (Argentina), Limited, 147, Queen Victoria Street, London, E.C.—Capital £20,000 in £1 shares (5,000 8 per cent. cumulative preference and 15,000 ordinary). Mechanical and electrical engineers, etc. Directors: G. A. Mower, G. R. Thursfield and L. M. Paterson.

Patent Specifications.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

20,324. Fuechsel, M. Welding metal pieces, particularly for welding rail clips to rail-road ties or sleepers. 298,309.

21,418. Heraeus Vacumschmelfe Akt.-Ges., and Rohn, W. Production of castings free from blow-holes. 298,324.

22,053. Cole, W. H. Proofing iron and steel against rust. 298,328.

25,034. Travis, I. D. Machines for casting molten metals. 298,355.

29,611. Pneulec, Limited, and Pritchard, P. Method of treating foundry sand, etc. 258,384.

30,232. Goodyear Tire & Rubber Company. Producing the corrosive action of acids upon iron and steel in pickling baths. 298,390.

31,634. Bell, W. J. Reconditioning sand for foundry moulding. 298,396.

31,802. Stanton Ironworks Company, Limited, and Wilkinson, A. Railway permanent-way chair keys. 298,398.

33,390. Fulton, W. M. Method and apparatus for drawing tubes. 298,407.

33,495. Kantzow, H. G. A. Fire-resistant alloys with high electric resistance. 298,408.

34,614. Soc. Anon. Le Progres Minier et Metallurgique, and Samsonow, A. de. Apparatus for agglomerating and roasting minerals. 283,133.

5,154. Compagnie de Produits Chimiques et Electro-Metallurgiques Alais, Froges, et Camarque. Manufacture of electrical conductors in light aluminium alloys. 286,254.

Personal.

Mr. Archibald A. Jamieson, a partner in the firm of Messrs. H. S. Lefevre & Company, has been appointed a director of Messrs. Vickers, Limited.

Sir Alfred Herbert, it is announced, has promised to present to the Rugby College of Technology and Arts machinery to equip the new engineering wing now in course of erection.

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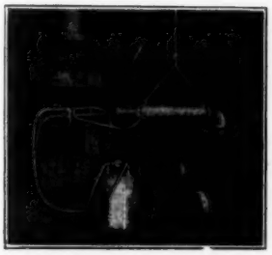

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—In the ordinary course of events, the current quarter should be one of the busiest periods of the year for the Cleveland pig-iron trade, but, unfortunately, circumstances have determined otherwise, and so far there seems little prospect of betterment during the months of winter yet to come. Convincing evidence of that fact is found in the obstinate reluctance of buyers to enter into further forward commitments, business in the Teeside market being at present almost entirely reduced to week-to-week purchases of retail dimensions. In justification of this policy consumers argue that, with the approaching reduction of railway rates for fuel and other raw material, there must be in the near future a corresponding decrease in production costs of pig-iron, in which they will be entitled to share to the extent of some lowering of prices for Cleveland material from the high levels now quoted. Whether this argument will be confirmed by results remains undecided, but meantime makers adhere firmly to their previous home and export quotations, as follow:—No. 1 Cleveland foundry iron, 68s. 6d. per ton; No. 3 G.M.B., 66s.; No. 4 foundry iron, 65s.; No. 4 forge iron, 64s. 6d. Progressive improvement continues in the hematite market in the North-East Coast section of the industry, the current output passing into prompt consumption, while a steady flow of forward business is a further gratifying sign of prevailing activity. Prices also keep very steady, with East Coast mixed numbers at 70s. per ton and No. 1 quality at 70s. 6d. On the North-West Coast Bessemer mixed numbers are quoted at 70s. to 70s. 6d. at works.

LANCASHIRE.—The local markets for foundry pig remain somewhat irregular as regards current business, and few transactions on forward account are reported. Prices, however, continue firm, with Derbyshire No. 3 quoted at about 68s., and Staffordshire similar quality, 67s. 6d., both delivered Manchester or equal distance, with Scottish brands at 87s. 6d. to 90s., also delivered consumers' works.

THE MIDLANDS.—At Birmingham this week consumers' purchases were mostly confined to small tonnages for prompt delivery, for which the following rates were quoted:—Northamptonshire No. 3, 55s. 6d. to 56s. 6d.; North Staffordshire No. 3, about 60s., both at furnaces.

SCOTLAND.—So far as the Scottish markets for foundry pig are concerned, business remains at a minimum level, with few signs of an early recovery, unless the strike troubles in Germany should deflect some orders in this direction. Prices, however, are undisturbed, quotations ruling at the old figures:—Foundry No. 3, 70s.; No. 1 quality, 75s. per ton f.o.t.

Finished Iron.

Although the South Staffordshire nut and bolt works are taking somewhat bigger supplies of Lancashire bar iron, the extent of the improved demand from this direction has been less than had been anticipated. Local makers are still hoping that continued high prices for imported material will eventually result in greater benefit to them. Meanwhile, values are steady at £10 per ton for crown bars and £9 10s. for seconds. Merchant parcels of the former are quoted on the basis of 14s. per cwt., less 2½ per cent., and including delivery to buyers' works. South Staffordshire marked bars remain firm at £12 per ton.

Steel.

In the markets for steel, business generally is brisk, the principal result of the German lockout having been an advance of about 2s. 6d. in the price of certain classes of semi-finished steel by some of the British manufacturers. In the finished steel department of the market there is little alteration. Most of the British works have experienced a rather better demand during the past week than earlier in October; but there is still a considerable amount of unemployed plant. The tinplate market continues quietly steady, values standing at about 18s. to 18s. 1½d. basis, f.o.t. at works, for usual lines. Wasters are moving quietly at scheduled rates.

Scrap.

Markets for this class of foundry material remain quiet and generally uninteresting to consumers, but with little variation in prices at the principal centres of the trade. In the Tees-side area the foundries are still slack, and are only taking limited quantities of heavy cast iron, for which 60s. per ton is still the ruling figure. Machinery quality in handy sizes realises round about 65s. In Scotland the foundries are more or less off the market, with the result that merchants are finding difficulty in getting outlets. The price of machinery cast-iron scrap is unchanged at 65s., and for heavy ordinary 60s. to 61s. is quoted. Old cast-iron railway chairs are still at 64s. to 65s., with few buyers, and light cast iron is 57s. 6d., with cast-iron firebars at 55s. These prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Markets for non-ferrous metals fully maintain the firmness recently marked in current values, and in the case of warrant copper continue a steadily upward tendency. The improvement is apparently due to the sustained briskness in demand which has been the feature of the market lately, but which has now eased off somewhat. The position at present seems to be that the excitement is at an end and that this market is settling down to a period of comparative calm.

Closing quotations are :—

Cash.—Thursday, £68 3s. 9d. to £68 5s.; Friday, £67 17s. 6d. to £67 18s. 9d.; Monday, £67 17s. 6d. to £67 18s. 9d.; Tuesday, £67 18s. 9d. to £68; Wednesday, £68 3s. 9d. to £68 5s.

Three Months.—Thursday, £68 12s. 6d. to £68 13s. 9d.; Friday, £68 7s. 6d. to £68 8s. 9d.; Monday, £68 6s. 3d. to £68 7s. 6d.; Tuesday, £68 7s. 6d. to £68 8s. 9d.; Wednesday, £68 11s. 3d. to £68 13s. 9d.

Tin.—Efforts on the part of speculative operators in the market for standard tin have apparently not been successful in forcing a further advance in prices, closing quotations ruling 40s. odd lower than at the end of the previous week. Advices from the United States suggest that the market there has been unwilling to follow the pace set by London. Consumption in this country is excellent, although users seem to be buying only as need arises. It is exceedingly difficult to make any reliable prediction as to the future of tin, as diametrically opposite opinions are heard on all sides.

Official closing prices :—

Cash.—Thursday, £231 to £231 5s.; Friday, £231 to £231 5s.; Monday, £230 12s. 6d. to £230 15s.; Tuesday, £230 to £230 5s.; Wednesday, £229 to £229 5s.

Three Months.—Thursday, £224 5s. to £224 7s. 6d.; Friday, £224 5s. to £224 7s. 5d.; Monday, £224 7s. 6d. to £224 10s.; Tuesday, £225 to £225 2s. 6d.; Wednesday, £223 10s. to £223 15s.

Spelter.—The market in this metal continues as stagnant as ever, in spite of the fact that there have been faint signs of greater activity lately. Prices for spot have risen above the £24 mark by a few shillings and do not seem to have been permanently affected by some fairly big declarations of metal for forward delivery. There do not at the moment appear to be any special grounds for optimism.

Daily quotations are :—

Ordinary.—Thursday, £24 5s.; Friday, £24 5s.; Monday, £24 6s. 3d.; Tuesday, £24 12s. 6d.; Wednesday, £24 13s. 9d.

Lead.—As yet there have been few signs of a revival of interest in the market for soft foreign pig, which continues inactive and dull. Anticipations of heavier arrivals from Australia have served to allay any anxiety consumers may have had about future supplies, and so, unless business becomes very much brisker than it has been for some time, there does not seem to be any need to expect an advance in values.

Soft Foreign Prompt.—Thursday, £21 5s.; Friday, £21 3s. 9d.; Monday, £21; Tuesday, £21; Wednesday, £21 3s. 9d.

Open-Hearth Investigations of the United States Bureau of Mines.

At a meeting of the Department of Commerce, held recently, Mr. C. H. Herty outlined the activities of the Metallurgical Advisory Board appointed by the United States Bureau of Mines, in conjunction with the Carnegie Institute of Technology, to consider more fully the fundamental principles involved in steel making. The total cost of the research is approximately $44,000 per year.

The laboratory equipment includes a 50-k.v.a. Ajax-Northrup high-frequency furnace capable of melting from 50 to 125 lbs. of metal; also a 35-k.v.a. Ajax high-frequency furnace for making smaller melts, particularly for making up synthetic slags. Most of the ingots for the studies on deoxidation are made in a furnace of 250 lbs. capacity, and there are other smaller furnaces used for special work. Crucibles are carefully considered, and for basic slags, crucibles made of fused magnesia, bonded with hydrochloric acid, have been most successfully used. Small fused magnesia crucibles with no bonding material have been made by firing in graphite in the 35-k.v.a. induction furnace, and have given excellent results. For acid slags, silica crucibles are used, but it has been found well-nigh impossible to prevent erosion of the crucible with acid slags high in iron oxide. Graphite crucibles are used whenever a reducing type of slag is being made and when the carbon content of the metal is not required to be low; graphite is also used in making up some of the synthetic slags.

The slag problem forms a large portion of the programme, consideration being given to such questions as how many impurities a slag will absorb from the steel in a given length of time; how fast does iron oxide, the agent for the removal of carbon, manganese, phosphorus, silicon, and other impurities from the metal, dissolve in the metal from a given type of slag; and what changes occur in other physical properties with changes in slag composition? These are some of the questions to be answered in this work.

Special attention is given to the determination of oxides in metals. The Ledebur method is used, and new methods are under investigation. The Dickenson method is also employed in instances where it has been found to be satisfactory. Attention is being centred on methods for the determination of MnO in steel.

The subject of inclusions is to be examined in four different standpoints, first a thorough study of deoxidation is being carried out under carefully controlled conditions, and various types of inclusions are formed in the steel and trapped by rapid cooling of small ingots. Studies on degree of deoxidation, action of the inclusions in the liquid steel, forging properties, corrosion and physical testing of the steel, and other tests are being carried out on steels treated with a large number of deoxidisers, from the simple alloys ferro-silicon, ferro-manganese and aluminium to complex ternary alloys of these three. The special deoxidisers, zirconium, titanium and vanadium, are also being investigated, although not so extensively as the first three named. Second, the oxides resulting from deoxidation of steel with any element are being studied separately. Third, investigations on the formation and elimination of inclusions, as indicated by laboratory tests, are being carred out in open-hearth furnaces of 40- to 300-ton capacity, and on steels varying from 0.08 to 0.90 per cent. in carbon content. Both acid and basic steels are being studied. Fourth, studies of the effects of non-metallic inclusions on the rolling quality, surface, and tensile properties of steel are being carried out.

British Science Guild Report on Patent Law Reform.—The British Science Guild's long-promised Report on the reforms needed in the patent system has now been published. "Patents undoubtedly have a close bearing on the unemployment problem," said an official of the Guild recently. In his opinion, the proposals in the Report will, if adopted, go far to remedy some of the well-known defects of our patent system, such as the grant of numerous invalid patents, the costly delays which at present harass the inventor, and even to some extent the financial hardships which arise.

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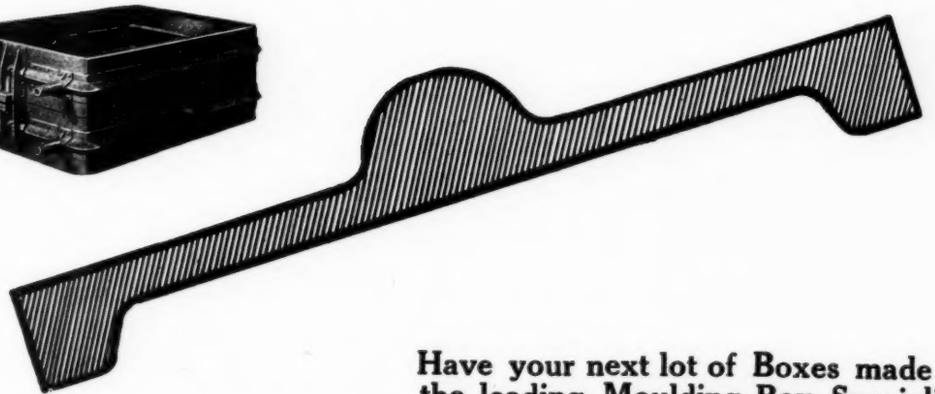

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WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	68 3 9
Three months	68 11 3
Electrolytic	74 15 0
Tough	72 0 0
Best selected	72 10 0
Sheets	98 0 0
India	80 0 0
Wire bars	75 2 6
Do. November	75 2 6
Do. December	75 2 6
Ingot bars	75 2 6
H.C. Wire rods	79 5 0
Off. av. cash, October	65 11 4 3/13
Do. 3 mths., October	66 0 5 23/26
Do., Sttlmnt. October	65 11 2 9/13
Do., Electro, October	72 3 5 11/13
Do., B.S., October	66 11 4 5/13
Aver. spot price, copper, Oct.	—
Do., Wire bars, October	72 8 3 3/13
Solid drawn tubes	13¾d.
Brazed tubes	13¾d.
Wire	10¼d.

BRASS.

Solid drawn tubes	12d.
Brazed tubes	14d.
Rods, drawn	11⅞d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	10½d.
Wire	10⅞d.
Rolled metal	10⅞d.
Yellow metal rods	10¼d
Do. 4 × 4 Squares	7½d.
Do. 4 × 3 Sheets	8d.
	8¼d.

TIN.

	£ s. d.
Standard cash	229 0 0
Three months	223 10 0
English	227 0 0
Bars	230 0 0
Straits	229 0 0
Australian	229 0 0
Eastern	227 0 0
Banca	229 0 0
Off. av. cash, October	222 2 1 12/13
Do., 3 mths., October	219 18 5 3/13
Do., Sttlmt., October	222 1 7 13/13
Aver. spot, October	—

SPELTER.

	£ s. d.
Ordinary	24 13 9
Remelted	22 17 6
Hard	19 7 6
Electro 99.9	28 0 0
English	25 2 6
India	20 12 6
Zinc dust	(Nom.) 35 5 0
Zinc ashes	7 15 0
Off. aver., October	24 0 7 6/13
Aver., spot, October	—

LEAD.

	£ s. d.
Soft foreign ppt.	21 3 9
English	22 10 0
Off. average, October	22 1 6 6/13
Average spot, October	—

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	33 0 0
Do. V.M. ex whf.	31 5 0
Rods	39 0 0
Boiler plates	29 0 0
Battery plates	30 10 0

ANTIMONY.

	£ s. d.
Special brands, Eng.	57 10 0
Chinese	40 0 0
Crude	33 10 0

QUICKSILVER.

	£ s. d.
Quicksilver	22 17 6

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	7 17 6
45/50%	12 0 0
75%	19 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/3 lb. Mo.
Ferro-titanium—	
23/25% carbonless	1/1 lb.
Ferro-phosphorus, 20/25%	£18 0 0
Ferro-tungsten—	
80/85%, c. fr.	1/3 lb.
Tungsten metal powder—	
98/99%	1/7½ to 1/8 lb.
Ferro-chrome—	
2/4% car.	£30 0 0
4/6% car.	£21 2 6
6/8% car.	£20 0 0
8/10% car.	£20 0 0
Ferro-chrome—	
Max. 2% car.	£32 10 0
Max. 1% car.	£37 0 0
Max. 0.70% car.	£42 0 0
70% carbonless	1/- lb.
Nickel—99%, cubes or pellets	£175 0 0
Ferro-cobalt	9/- lb.
Aluminium 98 99%	£98 0 0
Metallic chromium—	
96/98%	2/7 lb.
Ferro-manganese (net)—	
76/80% loss	£13 15 0
76/80% packed	£14 15 0
76/80%, export	£14 10 0
Metallic manganese—	
94/96%, carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 3
Finished bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Hvy. steel	3 7 6	to 3 8 6
Bundled steel and shrngs.	3 2 6	to 3 6 6
Mixed iron and steel	3 0 0	to 3 2 0
Heavy cast iron	2 16 0	to 2 17 6
Good machinery for foundries	3 0 0	
Cleveland—		
Heavy steel	2 15 0	
Steel turnings	2 8 0	
Cast iron borings	2 2 6	
Heavy forge	3 7 6	
Bushelled scrap	2 18 6	
Cast-iron scrap	3 2 6	
Lancashire—		
Cast-iron scrap	2 15 0	to 3 5 0
Hvy. wrought	3 5 0	
Steel turnings	2 5 0	
London—Merchants' buying prices delivered yard.		
Copper (clean)	54 0 0	
Brass	39 0 0	
Lead (less usual draft)	18 10 0	
Tea lead	15 10 0	
Zinc	15 10 0	
New aluminium cuttings	62 0 0	
Braziery copper	50 0 0	
Gunmetal	50 0 0	
Hollow pewter	150 0 0	
Shaped black pewter	105 0 0	

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	70/6
Hematite M/Nos.	70/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/-
,, d/d Birm.	86/-
Midlands—	
Staffs. common*	67/6
,, No. 4 forge	56/-
,, No. 3 fdry.	60/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	54/0
,, fdry. No. 3	56/6
Derbyshire forge	59/-
,, fdry. No. 3	60/6
,, basic	65/-
Scotland—	
Foundry No. 1	75/-
,, No. 3	70/-
Hem. M/Nos.	74/-
Sheffield (d/d district)—	
Derby forge	61/-
,, fdry. No. 3	65/-
Lincs. forge	63/-
,, fdry. No. 3	64/6
E.C. hematite	81/-
W.C. hematite	84/-
Lincs. (at furnaces)—	
Forge No. 4	58/-
Foundry No. 3	60/-
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	68/6
Northants foundry No. 3	—
Dalzell, No. 3(special)	100/- to 102/6
Summerlee, No. 3	87/6 to 90/-
Glengarnock, No. 3	87/6 to 90/-
Gartsherrie, No. 3	87/6 to 90/-
Monkland, No. 3	87/6 to 90/-
Shotts, No. 3	87/6 to 90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.) nom.		10 5 0
Nut and bolt iron	8 12 6	to 9 0 0
Hoops		11 10 0
Marked bars (Staffs.) f.o.t.		12 0 0
Gas strip		11 10 0
Bolts and nuts, ½ in. × 4 in.		15 5 0
Steel—		
Ship plates	8 7 6	to 8 12 6
Boiler plts.		10 10 0
Chequer plts.		10 12 6
Angles		7 17 6
Tees		8 17 6
Joists		7 17 6
Rounds and squares, 3 in. to 5½ in.		8 17 6
Rounds under 3 in. to ½ in. (Untested)		7 15 0
		and upwards
Flats, over 5 in. wide and up		8 7 6
Flats, 5 in. to 1½ in.		7 17 6
Rails, heavy		8 10 0
Fishplates		12 10 0
Hoops (Staffs.)		10 10 0
Black sheets, 24g.	10 0 0	to 10 10 0
Galv. cor. shts. 24g.	13 10 0	to 13 15 0
Galv. fencing wire 8g. plain		12 10 0
Billets, soft	6 5 0	to 6 10 0
Billets, hard	7 2 6	to 7 12 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE.

	Per lb. basis
Strip	1 2½
Sheet to 10 w.g.	1 3½
Wire	1 4½
Rods	1 3½
Tubes	1 7½
Castings	1 2½

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.70
No. 2 foundry, Valley	17.00
No. 2 foundry, Birm.	16.26
Basic	19.76
Bessemer	19.76
Malleable	18.76
Grey forge	18.90
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	33.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.50
Sheets, blue an'l'd, 9 and 10	2.00
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplates, 100 lb. box	$5.25

COKE (at ovens)

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	16/-
,, furnace	14/3
Midlands, foundry	—
,, ,, furnace	13/6 to 14/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20 × 14 box	18/- to 18/3
,,	28 × 20 ,,	36/-
,,	20 × 10 ,,	26/3
,,	18¾ × 14 ,,	18/9
C.W.	20 × 14 ,,	14/9
,,	28 × 20 ,,	33/6
,,	20 × 10 ,,	21/-
,,	18¾ × 14 ,,	15/-
Terneplates	28 × 20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 10 0
Bars, hammered, basis	£17 10 0 to £18 10 0
Bars & nailrods, rolled, basis	£15 15 0 to £16 15 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£20 0 0 to £24 0 0
Bars & rods, dead soft, steel	£10 0 0 to £14 0 0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£ s. d.	
Nov. 8 ..	68 3 9	inc. 13/9
„ 9 ..	67 17 6	dec. 6/3
„ 12 ..	67 17 6	No change
„ 13 ..	67 18 9	inc. 1/3
„ 14 ..	68 3 9	„ 5/-

Electrolytic Copper.

	£ s. d.	
Nov. 8 ..	75 0 0	inc. 5/-
„ 9 ..	75 0 0	No change
„ 12 ..	74 15 0	dec. 5/-
„ 13 ..	74 15 0	No change
„ 14 ..	74 15 0	

Standard Tin (cash).

	£ s. d.	
Nov. 8 ..	231 0 0	dec. 10/-
„ 9 ..	231 5 0	inc. 5/-
„ 12 ..	230 12 6	dec. 12/6
„ 13 ..	230 0 0	„ 12/6
„ 14 ..	229 0 0	„ 20/-

Tin (English ingots).

	£ s. d.	
Nov. 8 ..	227 10 0	dec. 30/-
„ 9 ..	227 10 0	No change
„ 12 ..	227 15 0	inc. 5/-
„ 13 ..	227 10 0	dec. 5/-
„ 14 ..	227 0 0	„ 10/-

Zinc Sheets (English).

	£ s. d.	
Nov. 8 ..	33 0 0	No change
„ 9 ..	33 0 0	„ „
„ 12 ..	33 0 0	„ „
„ 13 ..	33 0 0	„ „
„ 14 ..	33 0 0	„ „

Spelter (ordinary).

	£ s. d.	
Nov. 8 ..	24 5 0	inc. 1/3
„ 9 ..	24 5 0	No change
„ 12 ..	24 6 3	inc. 1/3
„ 13 ..	24 12 6	„ 6/3
„ 14 ..	24 13 9	„ 1/3

Lead (English).

	£ s. d.	
Nov. 8 ..	22 15 0	dec. 20/-
„ 9 ..	22 10 0	„ 5/-
„ 12 ..	22 10 0	No change
„ 13 ..	22 5 0	dec. 5/-
„ 14 ..	22 10 0	inc. 5/-

Exports of Iron Castings in October and the ten months 1928, compared with October and the ten months 1927.

	October, 1927.	October, 1928.	Ten months, 1927.	Ten months, 1928.	October, 1927.	October, 1928.	Ten months, 1927.	Ten months, 1928.
BUILDERS' CASTINGS— Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers:—	Tons.	Tons.	Tons.	Tons.	£	£	£	£
To Argentine Republic	98	195	1,309	1,522	3,623	6,257	49,386	61,380
„ British South Africa	360	190	2,412	2,831	12,313	7,814	87,332	100,471
„ „ India	129	79	946	1,178	5,878	3,259	42,934	51,213
„ Australia	59	35	773	524	3,811	2,499	44,813	36,326
„ New Zealand	101	174	1,657	1,551	6,205	10,170	84,724	80,860
„ Other countries	788	614	6,918	7,599	39,399	30,403	346,740	355,741
Total	1,535	1,287	14,015	15,205	71,229	60,402	655,929	685,991
PIPES AND FITTINGS—CAST—								
To Argentine Republic	894	975	7,838	7,884	9,947	8,854	86,679	80,048
„ British South Africa	2,943	1,074	11,535	4,588	28,186	10,757	130,184	65,154
„ „ India	743	309	5,804	6,681	10,802	5,523	89,661	90,295
„ Straits Settlements and Malay States	823	2,530	12,409	13,958	8,656	18,599	121,727	124,648
„ Ceylon	60	1,640	1,185	3,271	747	13,755	13,876	30,376
„ Australia	843	1,376	7,714	8,713	11,541	12,824	92,845	92,894
„ Other countries	5,715	4,011	51,842	46,694	70,579	50,578	673,784	607,671
Total	12,021	11,915	98,328	91,789	140,458	120,890	1,208,756	1,091,086
HOLLOW-WARE— Cast, not Enamelled, and Cast, Tinned	428	474	3,908	3,817	15,457	18,406	152,945	144,963
„ Enamelled	54	86	579	652	6,129	8,406	60,700	62,838
CASTINGS, in the rough— Iron	86	164	995	1,370	3,516	6,445	36,258	43,802
Steel	127	128	856	583	6,029	3,719	39,816	24,783

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

PIG

IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

IRON MOULDER, age 32, desires change; 15 years' experience on light and heavy engineering work; present position charge hand; also conversant with technical foundry practice, including cupola practice.—Box 882, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MOULDER, at present in U.S.A., desires position any part England or Scotland; eighteen years' experience in iron and brass, six years' experience on mass production in brass, expert on bench, plate and machine moulding on piecework system, desires permanent position where there is opportunity for advancement.—Box 872, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRY PIG-IRON.—Position wanted as Resident Engineer, Birmingham or Manchester, for the direct supply from furnaces; no agents.—Write, Box 884, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

ROLL MAKERS.—Practical Metallurgist seeks position; unusually wide experience in straight chilled and alloy rolls; intimate contact with sheet and tinplate trades; technical or commercial duties.—Box 854, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MOULDING Machine Pattern Plate Maker, with experience of French System, Wanted at once.—State experience, age and wage required in confidence to Box 12, G.P.O., West Bromwich.

FOREMAN for Iron Foundry in North-West England, employing about 40 hands on marine engine and electrical plant castings; must be fully conversant with all classes of moulding and the most up-to-date methods to obtain maximum output; state full details of experience and salary required.—Box 888, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

REPRESENTATIVE, with technical and sales experience, and able to estimate and quote for work, required by old-established firm of Iron and Brass Founders.—Reply in confidence, stating age, experience and salary required, etc., to Box 886, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PATENTS AND TRADE MARKS.

INFORMATION HANDBOOKS, Advice, and Cons. free; King's Patent Agency, Ltd.—B. T. KING, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A., and Can.), 146A, Queen Victoria Street, E.C.4. 40 years' refs. 'Phone: 0682 Central.

AGENCY.

FOUNDRY ENGINEER, with office East Midlands, is open for further Agencies; offers invited; confidential; good references; able to demonstrate.—Box 876, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PROPERTY.

11 ACRES WORKS SITE, SHEFFIELD.

145,000 Sq. Ft. of SHOPPING, Compact and Convenient.

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with L.M. & S. and L. & N.E. Rlys.

WELL-BUILT & COMMODIOUS OFFICES

Will Sell whole or in lots to suit customers, or Let on favourable terms. Unique opportunity for Manufacturers.

Apply—

THOS. W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.

MACHINERY.

CUPOLA, 15-20 cwt. per hour, complete with Sturtevant fan and piping, inspection peeps, ladles and irons; perfect condition; outline blue print available; £30.—RECEIVER, Victor Ashby & Son, Limited, Towcester.

No. 3 CINCINNATI Universal Cylindrical Grinding Machine, 12 in. x 48 in.

Nearly New 12-in. x 42-in. LANDIS Plain Cylindrical Grinding Machine.

CHURCHILL 8-in. x 16-in. Plain Grinding Machine, gear box drive.

DIAMOND Surface Grinding Machine, with magnetic chuck 2 ft. 8 in. x 10 in.

5-ton "GRAFTON" LOCO. STEAM CRANE, 35-ft. steel jib, 4-ft. 8½-in. gauge, 80 lbs. W.P.

3-ton "GRAFTON" LOCO. STEAM CRANE, 22-ft. 6-in. steel jib, 4-ft. 8½-in. gauge, 80 lbs. W.P.

Three LANCASHIRE BOILERS, 30 ft. x 8 ft., reinsure 150 lbs. pressure.

Two dish-ended LANCASHIRE BOILERS, by Thompson, 30 ft. x 8 ft., reinsure for 140 lbs. per sq. in. working pressure.

CATALOGUE (10,000 Lots) ON APPLICATION.

THOS. W. WARD LTD.,
ALBION WORKS, SHEFFIELD.

MACHINERY.—*Continued.*

WANTED, new or used Oil-fired Steel Converter Plant, 10- to 20-cwts. capacity; full particulars and where to be seen.—Apply, Box 856, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SAND MIXERS AND CORE-MAKING MACHINES.—Ask for our quotation for new Machines; prices from £14 upwards. Write for List.

SULRON, LIMITED,
FOUNDRY ENGINEERS,
CLOISTER WORKS,
CONGRESS STREET, SHEFFIELD.

Write to-day for our No. 1 Foundry Bulletin. Sent free on request.

SAND MIXERS.—New and second-hand. Ask us to quote.—W. BREALEY & COMPANY, LIMITED, Prospect Works, Hawksley Avenue, Sheffield.

STEEL FOUNDRY CRANE LADLES.—One 6-ton capacity, with worm tilting gear; one 15-ton capacity for bottom pouring.—For further particulars, write Box 870, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

STEAM CONDENSER, about 7 ft. 6 in. long, 3 ft. dia., with 900 sq. ft. cooling surface, 620 tubes 6 ft. 10 in. long by ¾ in. dia., capable of condensing 10,000 lbs. steam per hour, complete with or without electrically motor-driven 13-in. x 10-in. EDWARDS' AIR PUMP.—For further particulars, write Box 866, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

'Phone: 287 SLOUGH.

MOULDING MACHINES

FOUR 18"×18" Tabor Split pattern ..	£70 each
Two 40"×30" Tabor Shockless rollover	£160 each
One Hydraulic 60"×42" rollover ..	£110
Two Bonvillain machines (24" dia. boxes)	£120
Four No. 0 Britannia jolters	£20 each
One 24"×48" Tabor Shockless rollover	£140
One 18"×36" Tabor Shockless rollover	£110

ALL ABOVE IN PERFECT ORDER.

LARGEST STOCK OF FOUNDRY PLANT IN ENGLAND. PLEASE SEND FOR LISTS

BUY FROM ME AND SAVE MONEY.

ALEX. HAMMOND, *Foundry Machinery Merchant,*
14, AUSTRALIA ROAD, SLOUGH.

"PEASE & PARTNERS LTD"

DARLINGTON :: :: ::

Telephone: 2630 DARLINGTON.

Telegrams: "PEASE, DARLINGTON."

With our wide choice of RAW MATERIALS and long EXPERIENCE, we can supply you with the best fuel for YOUR CONDITIONS. Let us quote you.

DURHAM FOUNDRY COKES.